RESULTS OF THE SUMMER 2002 MONITORING SURVEYS OF THE 1997 CATEGORY II CAPPING PROJECT MOUND AT THE HISTORIC AREA REMEDIATION SITE

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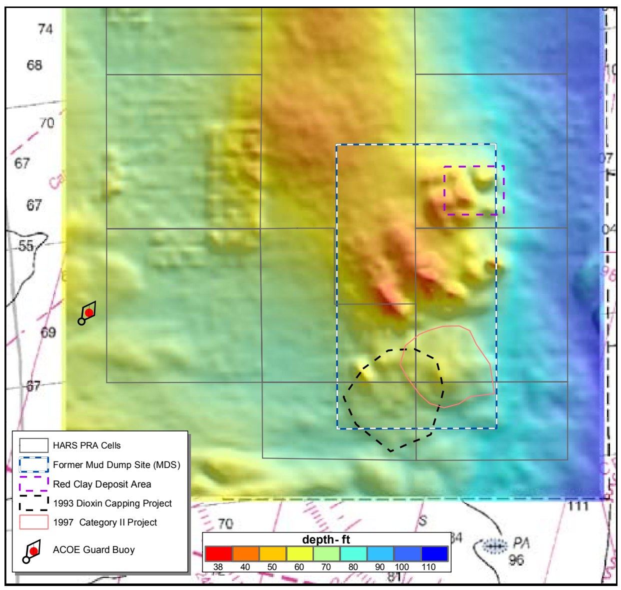

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ACKNOWLEDGMENTS

This report presents the results of the Summer 2002 Survey of the 1997 Category II Capping Project Mound at the Historic Area Remediation Site (HARS). This survey was conducted by Science Applications International Corporation (SAIC) of Newport, RI, under contract to U.S. Army Corps of Engineers—New York District (NYD). Dr. Stephen Knowles is the NYD's manager of technical activities; Mr. Raymond Valente is SAIC's program manager. Dr. Knowles provided logistical and planning support for the survey, with assistance from Mr. Tim LaFontaine of the NYD's Caven Point facility.

REMOTS sediment-profile imaging, benthic grab sampling and coring operations were conducted aboard the NYD's M/V *Gelberman*. Single-beam bathymetry, side-scan sonar and sub-bottom profiling survey operations were conducted aboard the M/V *Beavertail*, of Jamestown, RI. The crews of the M/V *Gelberman* and M/V *Beavertail* are commended for their skill in vessel handling while conducting all survey operations, as well as their dedication during long hours of operation at the HARS.

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Applied Marine Science (AMS) of League City, Texas, was responsible for the geotechnical analyses of both the sediment grab and core samples. Pace Analytical Services, Inc. of St. Paul, MN, (formerly Maxim Technologies, Inc.) conducted the chemical analyses of sediment core samples. Barry A. Vittor and Associates, Inc. (BVA) of Mobile, Alabama conducted the taxonomic analysis of the grab samples.

Pamela Walter and Ray Valente prepared this report in conjunction with Brian Andrews, Natasha Pinckard, Karen Shufeldt, and Tom Waddington. Michelle San Antonio and Megan Thomas were responsible for report production.

EXECUTIVE SUMMARY

From May to August of 1997, approximately 700,000 cubic yards of sediment containing low levels of dioxin and furan were dredged from Newark Bay and placed on the seafloor in the southern portion of the former Mud Dump Site in the New York Bight. The dredged material deposit was subsequently covered (capped) with approximately 2.4 million cubic yards of clean sand from the Ambrose Channel; the capping operation was completed in January 1998. In accordance with a comprehensive Monitoring and Management Plan developed jointly by the New York District of the U.S. Army Corps of Engineers and Region II of the U.S. Environmental Protection Agency, numerous monitoring surveys have been conducted prior to, during, and following both the dredged material and sand capping phases of the 1997 Category II Capping Project.

This report presents the results of several monitoring surveys completed during summer 2002 to evaluate the long-term stability of the sand cap and its continued effectiveness at isolating the dioxin and furan contaminants known to be present in the underlying dredged material. The summer 2002 field effort represents the latest in a series of postcap surveys that have been undertaken at regular intervals since the original completion of the capping operation in January 1998. The 2002 surveys included the following monitoring techniques: precision bathymetry, sub-bottom profiling, side-scan sonar, sediment vibracoring, REMOTS sediment-profile imaging, sediment plan view photography, and grab sampling for benthic community analysis.

The results of the summer 2002 precision bathymetric survey conducted over the 1997 Category II Capping Project Mound were compared to the results of the previous bathymetric survey of April 1999. The lack of depth change between the two surveys suggests no appreciable change in the distribution or thickness of the sand cap since its creation in 1998. This is the same result that has been observed in previous depth difference comparisons performed between successive postcap bathymetric surveys.

The results of summer 2002 sub-bottom acoustic profiling survey were consistent with the bathymetric depth differencing results, indicating an average sand cap thickness of 5 to 7 feet, with the greatest thickness (up to 9 feet) observed in the area of overlap between the 1993 and 1997 Mounds. Sediment cores obtained in August 2002 revealed an average cap thickness of 1.7 m (5.7 ft) over the 1997 Category II Mound. Cap thickness was variable among cores, ranging from 90 cm to greater than 264 cm. These results are consistent with previous postcap coring surveys and reflect small-scale spatial variability in cap thickness. Cap thickness measurements from the summer 2002 cores were generally comparable to the cap thickness estimates obtained through sub-bottom profiling.

The spatial distribution of clean, rippled cap sand detected at the 2002 REMOTS sediment-profile imaging stations was similar to that observed in several previous postcap REMOTS surveys over the 1997 Category II Capping Project Mound. Overall, the combined results of the summer 2002 bathymetric, sub-bottom profiling, coring, and REMOTS surveys support the conclusion that the sand cap has remained stable since its creation in 1998.

EXECUTIVE SUMMARY (CONTINUED)

Negligible (i.e., less than the 1 part per trillion) concentrations of dioxin and furan were measured in samples of the sand cap taken at various intervals in the cores. Detectable levels of dioxin and furan in samples of the underlying dredged material ranged from 0.4 to 22 parts per trillion. These results are consistent with those of previous postcap coring surveys and indicate a lack of any significant vertical migration of dioxin or furan from the underlying dredged material into the overlying cap material. These results support the conclusion that the sand cap continues to remain effective in isolating the dioxin and furan from the surrounding water and sediment environment.

The 2002 REMOTS sediment-profile imaging and sediment plan view photography results indicated that the surface of the sand cap continued to be inhabited by a benthic community comprised of small, surface-dwelling opportunists (Stages I and II), similar to the community at the nearby South Reference Area. In the area of the HARS immediately surrounding the capped mound, where fine-grained historic dredged material occurs, the benthic community consisted of a mixture of surface-dwellers (Stage I) and deeper-dwelling deposit-feeders (Stage III).

Benthic grab samples showed that several Stage I polychaetes and Stage II amphipods were among the most abundant organisms inhabiting the surface sediments at both the 1997 Category II Capping Project Mound and the South Reference Area. High numbers of the Stage II bivalve *Nucula proxima* were found in association with fine-grained historic dredged material in the area surrounding the capped mound. The benthic grab sampling results were generally consistent with the REMOTS results in showing that the 1997 Category II Mound and South Reference Area were both inhabited by relatively abundant and diverse benthic communities at the time of the summer 2002 surveys. Among-station differences in benthic community composition were attributed to differences in sediment grain size.

Both the REMOTS and benthic grab sampling results indicated that the surface of the 1997 Category II Capping Project Mound represented a relatively healthy and productive benthic habitat at the time of the summer 2002 survey.

LIST OF ACRONYMS

2,3,7,8–TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin (Dioxin)
2,3,7,8–TCDF	2,3,7,8-tetrachlorodibenzo-p-furan (Furan)
ANOSIM	Analysis of Similarities
ANOVA	analysis of variance
AMS	Applied Marine Sciences, Inc.
aRPD	apparent Redox Potential Discontinuity
ASTM	American Standard Testing Method
BVA	Barry A. Vittor and Associates, Inc.
CH4	CO_2 converted to methane
cm/sec	centimeters per second
CO_2	Carbon dioxide
CSV	comma delimited
CTD	conductivity-temperature-depth
CV	Coefficient of Variation (%)
DAMOS	Disposal Area Monitoring System
DGPS	Differentially-corrected Global Positioning System
DM	Dredged Material
DIVERSE	program within PRIMER
Eh	electro-chemical potential
EPA	Environmental Protection Agency
ft/sec	feet per second
g/cc	grams per cubic centimeter
GIS	Geographic Information System
GPS	Global Positioning System
HARS	Historic Area Remediation Site
HRGC	high resolution gas chromatography
HRMS	high resolution mass spectrometrykHz
kN	kiloNewotn
kPa	kiloPascal
LOD	limit of detection
LPIL	lowest practicable identification level
m	meter
m^2	square meters
M&MP	Management and Monitoring Plan
MDS	Mud Dump Site
MLLW	Mean Lower Low Water
mm	millimeter
m/sec	meters per second
M/V	Merchant Vessel
N	Newton
NAD 83	North American Datum of 1983
ng/kg	nanogram per kilogram
Nm	Newton meter
nMDS	non-metric Multi-dimensional scaling

LIST OF ACRONYMS (CONTINUED)

NOAA	National Oceanic and Atmospheric Administration
NYD	U.S. Army Corps of Engineers, New York District
OLLD	Ocean and Lake Levels Division
OSI	Organism-Sediment Index
PA	Pennsylvania
PARCC	precision, accuracy, representativeness, comparability and completeness
PCDDs	polychlorinated dibenzo-p-dioxins
PCDFs	polychlorinated dibenzo-p-furans
ppt	parts per thousand
pptr	parts per trillion
PRA	Priority Remediation Area
PRIMER	Plymouth Routines in Multivariate Ecological Research
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
QC	Quality Control
REMOTS	Remote Environmental Monitoring System
RPD	relative percent difference
USACE	U.S. Army Corps of Engineers
SADMA	Similar-Aged Dredged Material
SAIC	Science Applications International Corporation
SIMPER	program within PRIMER
SMMP	Site Management and Monitoring Plan
SPI	Sediment-profile Imaging
TCDD-EQ	TCDDEquivalant (Dioxin Equivalent)
TEC	Toxic Equivalent Concentration
TEF	Toxicity Equivalent Factors
TEQ	Toxic Equivalent
TIFF	Tagged Image File Format
TOC	Total Organic Carbon
TVG	time varied gain
UTC	Universal Time Coordinate
yd^3	cubic yards

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1.0 INTRODUCTION

Sediments dredged from New York Harbor were deposited at the Mud Dump Site (MDS), located in the New York Bight about six nautical miles east of Sandy Hook, New Jersey, until September 1997. Based on an agreement among the Environmental Protection Agency (EPA), the Department of the Army, and the Department of Transportation, the MDS and some surrounding historical dredged material disposal areas were re-designated as the Historic Area Remediation Site (HARS; Figure 1.1-1) beginning in September 1997.

The EPA Region II and the U.S. Army Corps of Engineers (USACE) New York District (NYD) are jointly responsible for managing the HARS, primarily in an effort to reduce the elevated contamination and toxicity of surface sediments to acceptable levels. The two agencies have prepared a Site Management and Monitoring Plan (SMMP) for the HARS that identifies a number of actions, provisions, and practices to manage remediation activities and monitoring tasks. Part of the planned remediation calls for the placement of a minimum one-meter thick layer of uncontaminated dredged material (defined as Category 1 material) to cap the existing surface sediments within each of nine Priority Remediation Areas (PRAs) of the HARS.

The HARS SMMP serves as a guideline document for the monitoring of the PRAs during the course of remediation efforts. The recommended routine monitoring tools in the SMMP include high-resolution bathymetry, REMOTS sediment-profile imaging (SPI), sediment coring, sediment chemistry and toxicity testing, tissue chemistry testing, benthic community analyses, and fish/shellfish surveys. Over the last several years, periodic monitoring surveys have been conducted in the HARS following the guidelines of the SMMP to document dredged material placement activities and overall environmental conditions.

This report presents the results of the summer 2002 survey operations over the 1997 Category II Capping Project Mound located near the southern boundary of the former Mud Dump Site. A suite of survey techniques were utilized, including single-beam bathymetry, sub-bottom profiling, side-scan sonar, REMOTS sediment-profile imaging, plan view imaging, benthic grab sampling, and geotechnical and chemical analysis of sediment vibracores. The survey operations over the 1997 Category II Capping Project Mound were one component of a larger summer 2002 monitoring effort at the HARS that included sampling at PRAs 1, 2, and 3, the 1993 Dioxin Capping Project Mound, and areas of previous red clay disposal. The results of these other survey efforts are presented in separate reports.

1.1 1997 Category II Capping Project Background

In 1990, the U.S. Army Corps of Engineers, NYD issued a permit to the Port Authority of New York and New Jersey (PA) for dredging and ocean disposal of approximately 500,000 cubic yards of sediment from berthing areas at the Port Newark/Port Elizabeth container ship terminal in Newark Bay, New Jersey. The sediments to be dredged had been found to contain trace levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD, hereinafter called dioxin) and 2,3,7,8-tetrachlorodibenzo-p-furan (2,3,7,8-TCDF, hereinafter called furan). These two chemicals are forms of classes of compounds known as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo-p-furans (PCDFs), respectively.

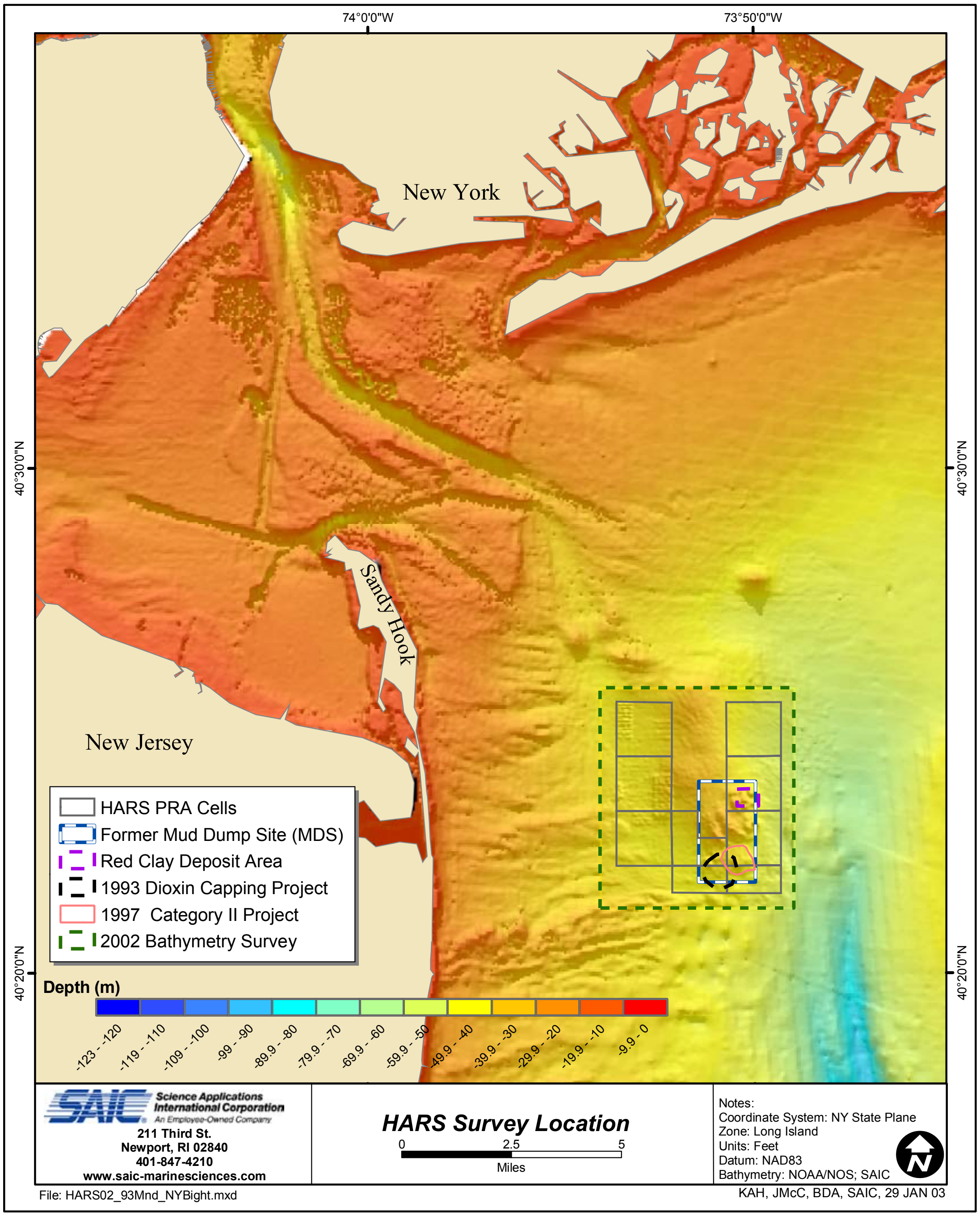


Figure 1.1-1. Map showing the location of the former Mud Dump Site (MDS) and Historic Area Remediation Site (HARS) in the New York Bight. The color-coded bathymetric data throughout the wide area surrounding the HARS are from the National Oceanic and Atmospheric Administration (NOAA) Coastal Relief Model Volume 1. The bathymetry at the HARS is from an SAIC survey conducted during summer 2002.

The dioxin-contaminated dredged material from Newark Bay was placed in the southern portion of the former MDS (Figure 1.1-2). The 1993 Dioxin Capping Project Mound placed an estimated 585,500 yd^3 of dredged material at the MDS in summer 1993 and subsequently capped this material with approximately 1.7 million cubic yards of clean sand. The second project involving dredging, disposal, and capping of dioxin-contaminated dredged material from Newark Bay was undertaken during the summer of 1997; this project is known as the 1997 Category II Capping Project. Approximately 700,000 yds^3 of material from selected berthing facilities at Port Newark and Elizabeth was placed in the southern portion of the former MDS next to the 1993 Dioxin Capping Project Mound and subsequently capped with approximately 2.4 million cubic yards of clean sand from Ambrose Channel (Figure 1.1-2). The disposal operation was completed in August 1997, and the capping operation was completed in January 1998. The MDS was officially closed in September 1997, when this site and its surrounding area were re-designated as the Historic Area Remediation Site (HARS).

Monitoring was conducted prior to, during, and following both the dredged material disposal and sand capping phases of the 1997 Category II Project (Figure 1.1-3). The comprehensive suite of monitoring techniques included high-resolution bathymetric surveying, REMOTS sediment-profile imaging, geotechnical analysis of surface sediments and benthic tissue samples and geotechnical and chemical analysis of sediment vibracore samples and sub-bottom profiling of sediment characteristics for mapping of mound stratigraphy.

Postcap monitoring at the 1997 Category II Mound has been conducted at regular intervals, with the most recent surveys taking place in May 1999 (i.e., two years following the completion of the capping operation). This monitoring has served to demonstrate that the cap material has remained in-place on the seafloor and has been effective at isolating the underlying dioxin-contaminated sediment. Furthermore, the monitoring has demonstrated that the surface of the cap has been effectively recolonized by benthic organisms.

1.2 2002 Survey Objectives

The overall goal of the 2002 survey effort over the 1997 Category II Capping Project Mound was to confirm that the sand cap continues to be present and has remained effective at isolating the underlying dredged material. This will in turn help to determine the need, or lack thereof, for any further placement of remediation material over this mound.

The summer 2002 monitoring effort therefore involved the following survey techniques and objectives:

- High-resolution bathymetric and side-scan sonar data were acquired over the 1997 Category II Capping Project Mound to detect changes in topography relative to the results of previous bathymetric surveys performed in April 1998 and March 1999 (Figure 1.1-3).

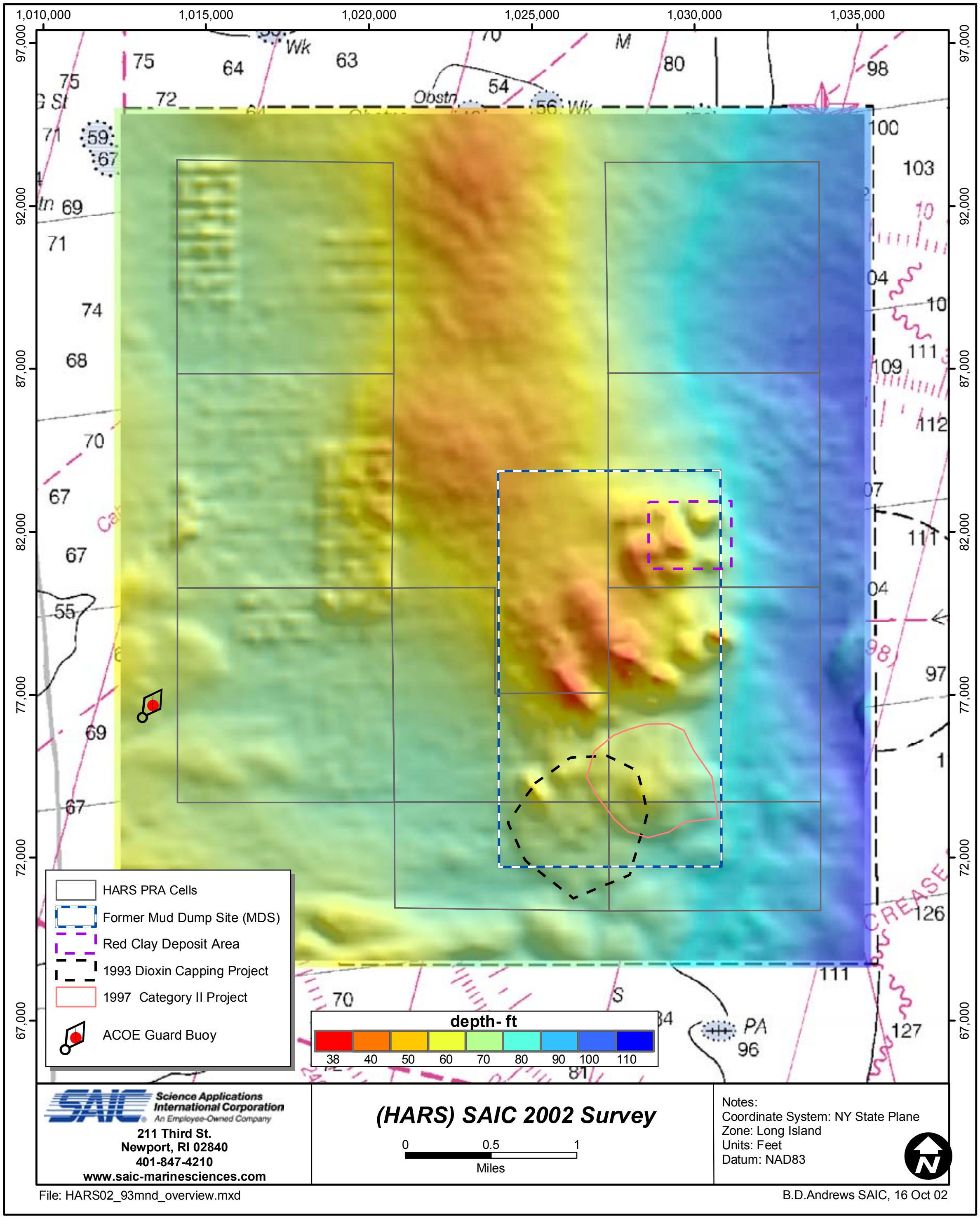


Figure 1.1-2. Location of the 1997 Category II Capping Project within the former Mud Dump Site and in relation to the Historic Area Remediation Site. Bathymetry is from the SAIC survey conducted during summer 2002.

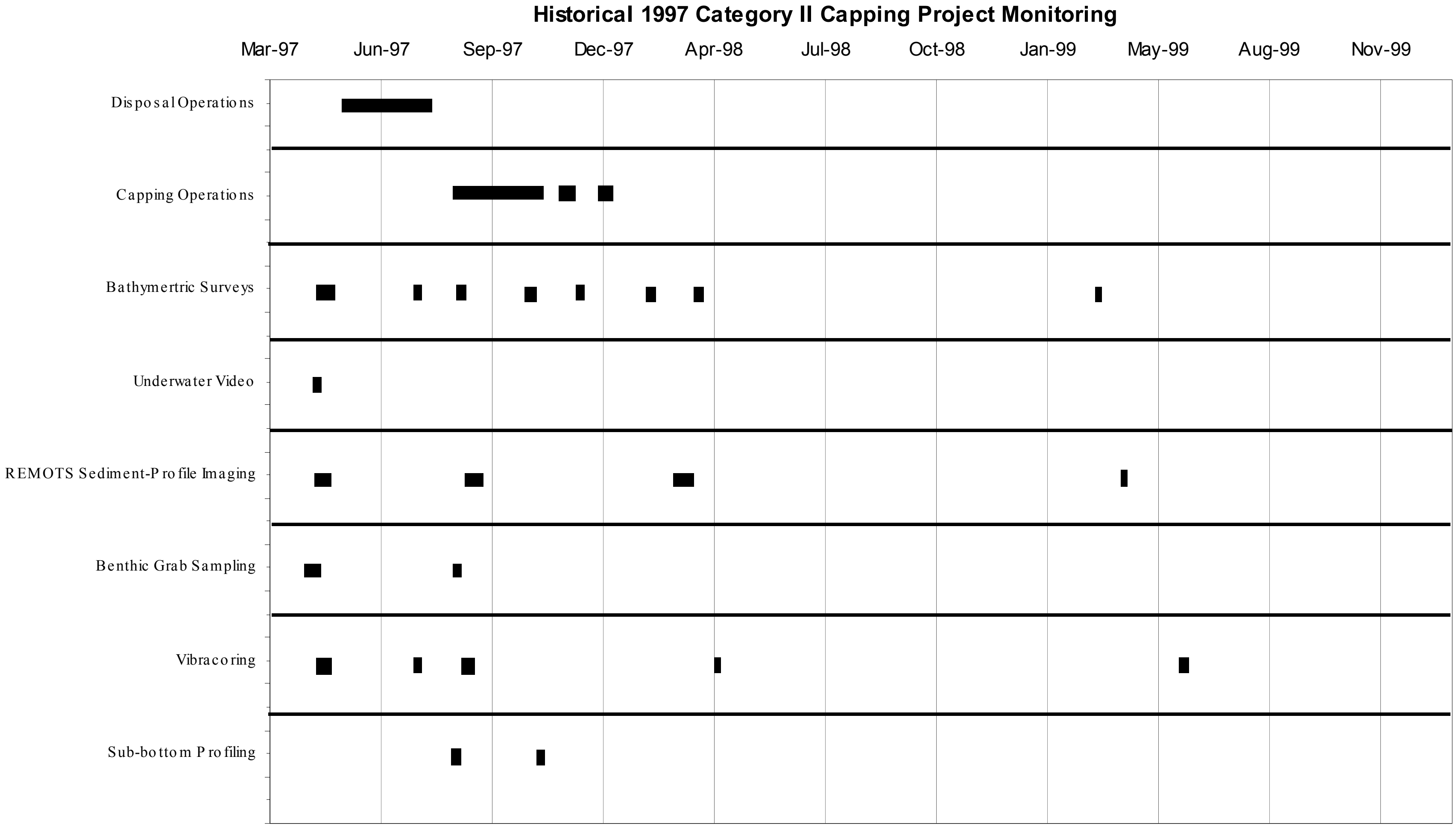


Figure 1.1-3. Historical 1997 Category II Capping Project timeline of material placement and past monitoring surveys

- High-resolution sub-bottom acoustic profiling data were collected over the 1997 Category II Capping Project Mound to identify and measure the thickness of any distinct sedimentary horizons, such as an upper coarse-grained sand cap; a fine-grained underlying dredged material layer, and the underlying ambient substrate. The results were compared to the previous sub-bottom profiling survey performed in late 1997 (Figure 1.1-3).

- REMOTS sediment-profile images and corresponding sediment plan view (i.e., downward-looking) images were collected over the capped mound to delineate the distribution of cap material and to assess the benthic recolonization status of the mound. In addition, sediment grab samples were obtained at 10% of the REMOTS stations for taxonomic identification of benthic organisms. The REMOTS stations occupied over the capped mound were identical to those occupied in previous surveys. In addition, REMOTS images and benthic grab samples were collected at the South Reference Area located approximately 3 km south of the HARS (Figure 1.2-1). The results from the South Reference Area provide a basis for comparison with the results from the 1997 Category II Capping Project Mound.

- Sediment vibracores were collected at a total of 14 stations located over the 1997 Category II Capping Project Mound to determine the thickness of the sand cap layer. Geotechnical and chemical analysis of samples from selected horizons within each sediment vibracore were used to confirm the long-term effectiveness of the cap material at isolating the underlying dioxin-contaminated sediment.

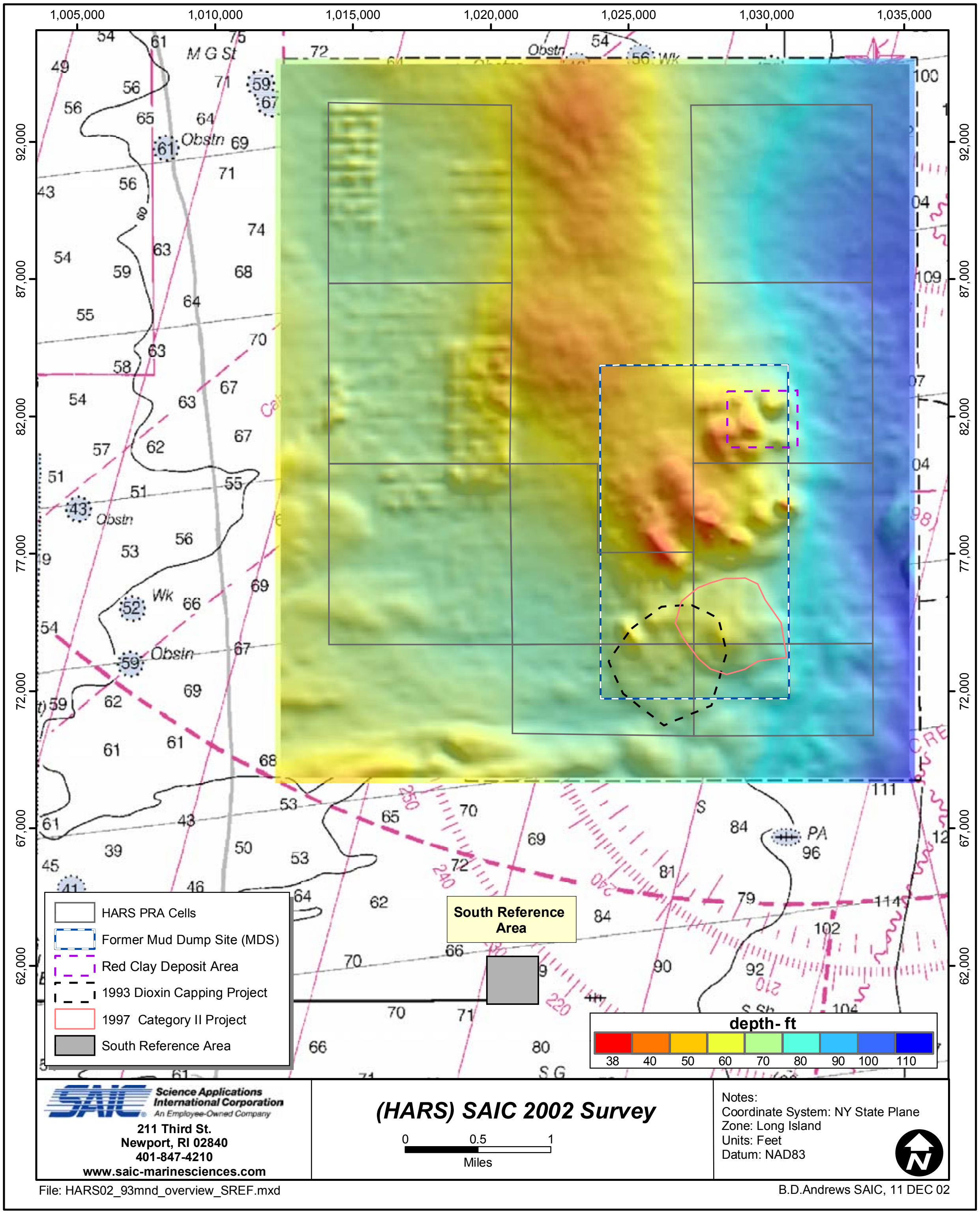


Figure 1.2-1. Location of the South Reference Area in relation to the Historic Area Remediation Site

2.0 METHODS

2.1 Field Operations

The summer 2002 surveys took place between June 19 and September 9, 2002. The M/V *Beavertail* operated by P&M Marine Services of Jamestown, RI was used for the bathymetric, sub-bottom and side-scan sonar surveys, while the M/V *Gelberman,* operated by the USACE NYD, was used for all the other survey work. Detailed methods are provided below for navigation and positioning; bathymetry, side-scan sonar, and sub-bottom profiling; REMOTS sediment-profile and sediment plan view imaging; benthic grab sampling and sediment vibracoring.

2.2 Navigation and Positioning

Differentially-corrected Global Positioning System (DGPS) data in conjunction with Coastal Oceanographic's HYPACK® navigation and survey software were used to provide real-time vessel navigation to an accuracy of ±3 m for each survey effort. A Trimble DSMPro GPS receiver was used to obtain raw satellite data and provide vessel position information in the horizontal control of North American Datum of 1983 (NAD 83). The DSMPro GPS unit also contains an integrated differential beacon receiver to improve overall accuracy of the satellite data to the necessary tolerances. The U.S. Coast Guard differential beacon broadcasting from Sandy Hook, NJ was utilized for real-time satellite corrections due to its geographic position relative to HARS.

The DGPS data were ported to HYPACK® data acquisition software for position logging and helm display. The target stations and survey lanes were determined prior to the commencement of survey operations and stored in a project database. Throughout the survey, individual stations and survey lanes were selected and displayed to position the survey vessel at the correct geographic location for sampling. All single point samples were collected within a set radius of the target location. To remain on station during the coring survey, the survey vessel was occasionally anchored, in a 2-point configuration. The position of each sample was logged with a time stamp in Universal Time Coordinate (UTC) and a text identifier to facilitate Quality Control (QC) and rapid input into a Geographic Information System (GIS) database for display use. During the bathymetric, side-scan sonar and sub-bottom profile surveys lanes were set up and run within a ±5 m window of the target center line. Vessel positioning was continuously logged during these surveys. DGPS navigation data were received, logged, and displayed in NAD 83 geographic coordinate system.

2.3 Bathymetric Survey

The bathymetric, side-scan sonar, and sub-bottom profile surveys over the 1997 Category II Capping Project Mound were completed in conjunction with a larger, more comprehensive survey conducted over the entire HARS from late July 2002 through early September 2002. A detailed discussion of this larger survey is presented in a companion report that provides detailed information on the techniques employed and overall bathymetric data quality (SAIC 2003a). An overview of the survey methods employed is provided in the following sections.

2.3.1 Field Methods

Coastal Oceanographic's HYPACKMax® survey and data acquisition software was used to provide the real-time interface, display, and logging of the vessel position and depth sounding data. Prior to field operations, HYPACKMax® was used to define a State Plane grid (New York – Long Island State Plane Coordinates) around the survey area and to establish the planned bathymetric and side-scan survey lanes. During the survey operations, the incoming navigation data were translated into state plane coordinates, time-tagged, and stored within HYPACK®. Depending on the type of field operations being conducted, the real-time navigation information was displayed in a variety of user-defined modes within HYPACKMax®.

Single-beam, bathymetric data, meeting the USACE Class I survey standards (USACE 2002), were acquired over the area encompassing both the 1993 Dioxin Mound and the 1997 Category II Mound (an area measuring approximately 7,100 ft by 12,800 ft) from 16 through 20 August 2002. Depth soundings, as well as sub-bottom profile and side-scan sonar data, were acquired continuously along 71 east-west main-scheme survey lanes spaced at 100 ft intervals (Figure 2.3-1). In addition, single-beam bathymetric data was also acquired along 15 north-south survey lines in conjunction with the side-scan sonar operations on 6 September 2002; the north-south survey lanes provided the data necessary to complete the required cross-check comparisons with the main-scheme bathymetric data (Figure 2.3-1).

During the bathymetric survey operations, the HYPACKMax® survey software was interfaced with an Odom Hydrotrac® survey echosounder, as well as the Trimble DGPS. The Hydrotrac® used a narrow-beam (3°), 208-kHz transducer, produced a continuous analog record of the bottom, and transmitted approximately 5 digital depth values per second to HYPACKMax®. Within HYPACKMax®, the time-tagged position and depth data were merged to create continuous depth records along the actual survey track. These records were viewed in real-time to ensure adequate coverage of the survey area.

The echosounder transducer was attached to an over-the-side pole mount that was deployed along the starboard side of the M/V *Beavertail.* An accurate horizontal distance offset was measured between the transducer and DGPS antenna and applied within HYPACKMax® during data acquisition. Though the vessel draft changed slightly during the course of the survey operations due to changes in vessel loading, the transducer draft was maintained at three feet throughout the survey by adjusting the height of the pole. The three-foot draft correction was applied directly to the raw echosounder data within the Hydrotrac® topside recorder and no further draft corrections were applied within HYPACKMax®. Based on settlement and squat tests conducted aboard the M/V *Beavertail* prior to the survey operations, the dynamic draft impacts at standard survey speeds (generally below six knots) were negligible.

A Seabird Electronics SBE-19® conductivity-temperature-depth (CTD) profiler was used to calculate vertical profiles of the water column sound velocity at the beginning, middle, and end of each survey day. On a few of the weather shortened survey days, only two CTD casts were obtained. Typically, at least one of the daily casts was taken in deeper waters along the eastern edge of the survey area to account for the sound velocity over the full range of depths

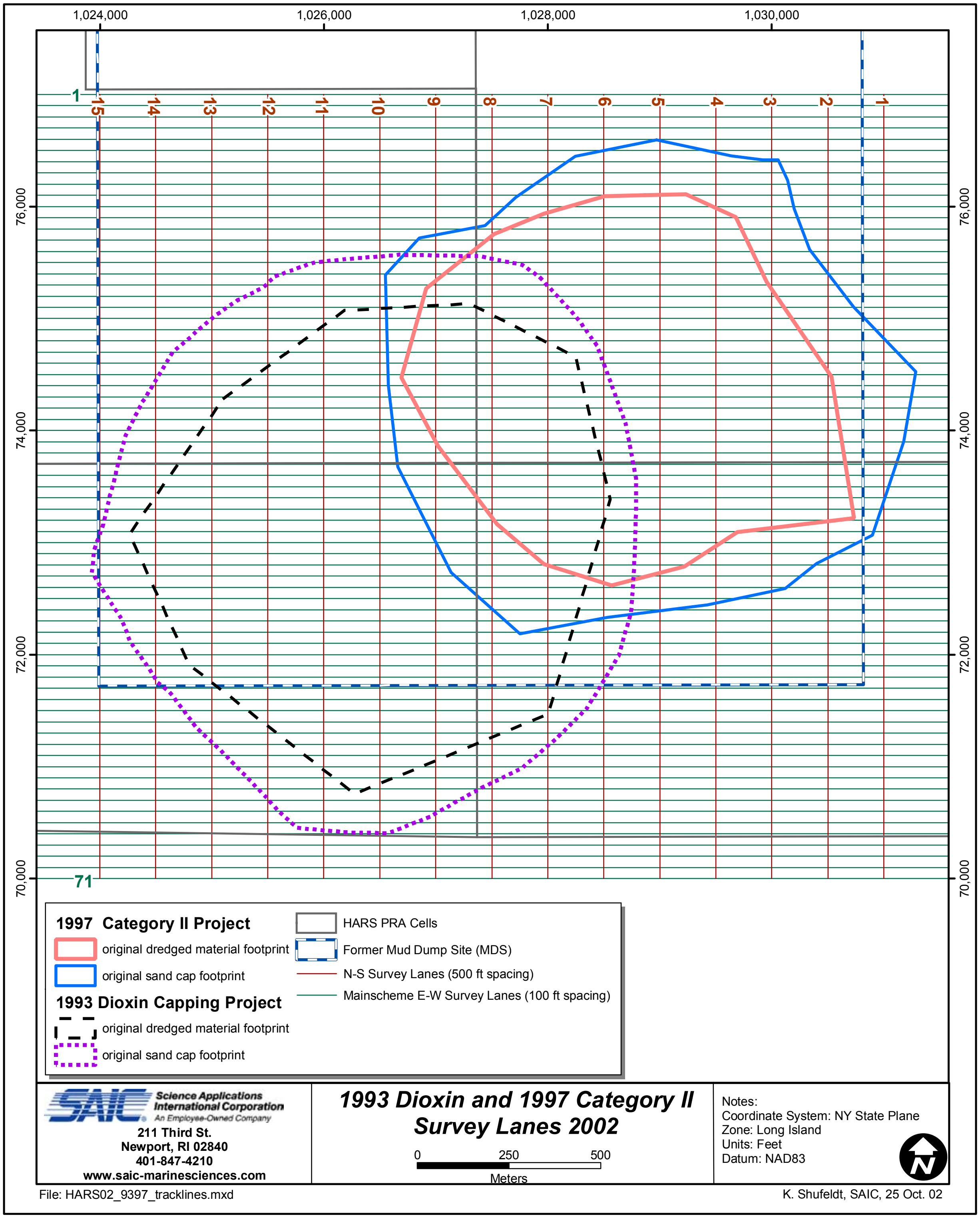


Figure 2.3-1. Survey lanes occupied during the summer 2002 single-beam bathymetry, side-scan sonar, and sub-bottom profile surveys

encountered during the survey. CTD sound velocity data were used to correct the raw echosounder data that were acquired using a constant assumed sound velocity of 4921 ft/sec (1500 m/sec).

To monitor tidal and other water level impacts during this survey, a bottom-mounted tide gauge was deployed along the western buffer zone of the HARS, adjacent to a guard buoy that was deployed by the USACE (Figure 1.1-2). Data from this gauge were used to make comparisons with the data from the primary National Oceanic and Atmospheric Administration (NOAA) tide gauge at Sandy Hook and to help document non-tidal water level differences between the HARS and Sandy Hook Bay. The tide gauge was deployed just prior to the start of survey operations and was recovered after the completion of the last survey lane. The gauge was checked sporadically during the survey and was also retrieved prior to a one-week down period in late August.

2.3.2 Bathymetric Data Processing

The bathymetric data were fully edited and processed using the HYPACKMax® single-beam data processing modules. Raw position and sounding data were edited as necessary to remove or correct questionable data, sound velocity corrections were applied, and the sounding data were reduced to Mean Lower Low Water (MLLW) using observed tides obtained from NOAA.

2.3.2.1 Sound Velocity Corrections

During bathymetric survey data acquisition, an assumed and constant water column sound velocity of 4921 ft/sec (1500 m/sec) was entered into the Odom echosounder. To account for the variable speed of sound through the water column, daily CTD sound velocity casts were taken at the beginning, middle, and end of each survey day. Each CTD cast was processed to produce a one-meter bin-averaged sound velocity profile from the sea surface down to the depth of the cast. The digital CTD cast data were grouped by day and stored within a master spreadsheet file for additional analysis and eventual export into HYPACKMax®.

After the daily sound velocity processing and analysis was completed, the data were used to generate a daily sound velocity profile table within HYPACKMax®. This average sound velocity table was based on a composite of all the casts obtained on a particular day and extended well beyond the deepest depth encountered on the survey. Based on the assumed sound velocity entered into the echosounder during data acquisition and the observed sound velocity reflected in the daily sound velocity profile table, HYPACKMax® computed and applied the required sound velocity corrections to all of the sounding records.

2.3.2.2 Tidal (or Water-Level) Corrections

Observed water level data from the NOAA primary tide station at Sandy Hook, NJ were obtained through NOAA's Ocean and Lake Levels Division's (OLLD) National Water Level Observation Network. The six-minute Sandy Hook tide data were periodically downloaded from the OLLD web site and the appropriate range and phase offsets were applied to transfer these data out to the HARS (http://www.co-ops.nos.noaa.gov). Based on conventions used in the past, a phase offset of –45 minutes and a ratio offset of 0.95 were applied to the observed Sandy Hook time and tidal height data. The corrected Sandy Hook water level data was then used to create daily tidal corrector files within HYPACKMax® that were then used to reduce all of the sounding data to the MLLW vertical datum.

In addition, the on-site bottom-mounted tide gauge was operational throughout the bathymetric survey operations and all tide data were successfully recovered from this gauge. Because the HARS tide gauge data were not referenced to any datum, the data had to be reduced to a consistent vertical datum before it could be compared to the Sandy Hook gauge data. In addition, because this gauge was periodically retrieved during the survey to ensure data recovery, the actual datum shifted slightly after each of these redeployments. Because of this slight datum shift, the HARS tide gauge data were grouped by each of the deployment periods. The final adjusted HARS tide gauge data were merged with the corrected Sandy Hook tide gauge data and grouped together by day within a master tidal spreadsheet for additional daily analysis and eventual export into HYPACKMax®.

2.3.2.3 Cross-Check Comparisons

After the bathymetric data were fully edited and reduced to MLLW, cross-check comparisons on overlapping data were performed to verify the proper application of the correctors and to evaluate the consistency of the data set. The survey pattern used for acquiring the bathymetric survey data yielded an extensive number of cross-check comparisons that could be made on overlapping data points from different survey lanes. Using the HYPACKMax® Statistics utility it was possible to systematically compute the differences between all points from different survey lanes that fell within a user-specified distance of each other. Despite a few feet of sea action during data acquisition, the somewhat irregular seafloor, and the distance separating the survey area from the actual tide station, the cross-check results were consistent for all surveys. A more thorough discussion of the bathymetric data quality results for this survey is presented in the companion report addressing the survey of the entire HARS (SAIC 2003a).

2.3.2.4 Data Reduction

After the data were verified, they were then run through the HYPACKMax® Mapper routine to reduce the size of the full data set in a systematic way. Because of the rapid rate at which a survey echosounder can generate data (approximately five depths per second), the along-track data density for a single-beam survey tends to be very high (multiple soundings per meter). In most cases, these data sets contain many redundant data points that can be eliminated without any effect on the overall quality of the data. The Mapper routine examines the full data set along each survey lane and averages all data points that fall within a user-specified grid cell to produce a single average value for each cell. The output from this routine is a merged, ASCII-xyz file that may contain anywhere from 2 to 10% of the original data set. These greatly reduced, but still representative, data sets are far more efficient to use in the subsequent modeling and analysis routines. In addition, the averaging algorithm helps to filter out the impacts of the sea action that was prevalent during most of the survey operations. For this survey, the data were mapped at an interval of 25 ft for later analysis.

2.3.3 Bathymetric Data Analysis and Presentation

The primary intent of this analysis was to evaluate the seafloor surface defined by the bathymetric data in an attempt to identify any unique features and to account for any observed differences with prior surveys. Because single-beam bathymetric survey data typically cover only a small percentage of the total seafloor area (approximately 5%), these analysis tools rely on a large degree of interpolation between the discrete survey data points to generate a three-dimensional seafloor surface model. This interpolation usually works well in flat or gently sloping areas, but in steep and irregular areas the interpolation of the surface can be very dependent upon the orientation of the survey lanes and the density of the data around the area.

The reduced 25-foot averaged trackline data were imported to ArcGIS 8.2 for gridding to a continuous raster surface. The Spatial Analyst extension for ArcGIS was used to explore the variance of the bathymetric trackline data and determine the optimal gridding parameters. Several gridding routines were investigated before final interpolation using Kriging. The Kriging method produces a variance grid along with the calculated surface. This variance grid provides a good indication of how well the chosen Kriging parameters calculated the surface. For this dataset, a 150-foot fixed search radius along with a spherical semivariogram model appeared to provide the best Kriging results (mean variance of 0.48 with a standard deviation of 0.18). The resulting gridded dataset was based on a 200-foot grid cell size and was comprised of 133 rows and 117 columns; this gridded dataset was used for all subsequent analysis and graphics production.

The primary analysis done on the final bathymetric gridded dataset was a depth difference comparison with the most recent prior bathymetric dataset. For the 1997 Category II Mound, this prior dataset originated from a postcap monitoring survey conducted in March 1999. Before the depth difference comparisons could be made, the prior dataset had to be reviewed for consistency, modified if necessary, and then gridded based on the same technique outlined in the preceding paragraph. Within ArcGIS 8.2, a bathymetric difference grid was then generated that helped illustrate the magnitude of change within this area since the last survey.

2.4 Sub-bottom Profiling and Side-Scan Sonar Survey

2.4.1 Field Methods

The sub-bottom profiling and side-scan sonar survey was conducted over the approximate footprint of the 1993 and 1997 Project Mounds and was acquired concurrently with the bathymetric data along 71 east-west and 15 north-south survey lanes that encompass the capped mound area (Figure 2.3-1). Sub-bottom profiling and side-scan sonar data were acquired with a Datasonics/Benthos SIS-1000® combined digital sub-bottom profiling and side-scan sonar system that was obtained to support this project from the USACE—Baltimore District. Because the SIS-1000 acquires sub-bottom and side-scan data simultaneously, all of the lanes occupied during the bathymetric survey operations over the capped mound areas (Figure 2.3-1) provided both data types. The SIS-1000 sub-bottom component operates at a swept frequency range of 2 to 7 kHz and the side-scan sonar component operates at a swept frequency range of 90 to 110 kHz. The SIS-1000® fish was towed behind the survey vessel with an armored signal cable that provided power to the towfish and two-way communication with the SIS1000® topside data acquisition system. This system recorded acoustic data from the towfish and position information from the navigation system, and displayed real-time sub-bottom imagery on a PC monitor.

Sub-bottom profiling is a standard technique used for distinguishing and measuring various sediment layers that exist below the sediment/water interface. Sub-bottom systems are able to distinguish these sediment layers by measuring differences in acoustic impedance between the layers. Acoustic impedance is a function of the density of a layer and speed of sound within that layer and is affected by differences in grain size, roughness, and porosity. Sound energy transmitted to the seafloor is reflected off the boundaries between sediment layers of different acoustic impedance. A sub-bottom system uses the energy reflected from these boundary layers to build the image. The depth of penetration and the degree of resolution of a sub-bottom system depends on the frequency and pulse width of the acoustic signal and the characteristics of the various layers encountered. In addition, because of the strength of the acoustic return signal normally associated with the seafloor reflector, it is often difficult to clearly distinguish sub-bottom horizons that are within a few feet of the seafloor surface.

Side-scan sonar systems provide an acoustic image of the seafloor by detecting the strength of the backscatter returns from signals emitted from a towed side-scan sonar transducer array. The side-scan transducers operate similar to a conventional depth-sounding transducer except that the towfish has a pair of opposing transducers aimed perpendicular to and directed on either side of the vessel track. Side-scan sonar data can reveal general seafloor characteristics and also provide the size and location of distinct objects. Dense objects (e.g., metal, rocks, coarse sand seafloor areas) will reflect strong signals and appear as dark areas in the records presented in this report. Conversely, areas characterized by soft features (e.g., silt, mud, or fine sand sediments), which absorb sonar energy, appear as light areas in the sample records.

2.4.2 Sub-bottom Profiling Data Processing and Analysis

Although sub-bottom data were acquired and recorded concurrent with all bathymetric survey operations over the mound areas, a file-formatting problem associated the older SIS-1000® topside operating system made it difficult to analyze any of the initial digital sub-bottom data acquired along the east-west survey lanes. Although a standard XTF file format was specified for storing this data within the SIS-1000® topside unit, this older XTF format was not compatible with the XTF file format supported by recent versions of available sub-bottom image analysis packages. After the data incompatibility issues were discovered, the SIS-1000® was returned to Datasonics/Benthos for evaluation and upgrade. Because a complete system upgrade was cost prohibitive under this contract, a minor modification was made to upgrade only the file formatting capability. During the subsequent north-south survey lanes run towards the end of this project, an older QMIPS file format was used to record the digital sub-bottom data.

After data acquisition, the sub-bottom data were analyzed and edited as necessary using the Chesapeake Technologies SonarWeb® software; some minor modifications were necessary to SonarWeb® to accommodate the older QMIPS data format. Because of the file formatting problems associated with the east-west sub-bottom data, most of the initial sub-bottom processing was focused on the north-south data. (Some of the east-west data were viewed manually to help confirm or enhance the north-south results.) SonarWeb® enables manual detection, tracking, and digitizing of any sub-bottom layers that are present in the data and also allows the data to be re-displayed under a variety of different configurations.

The process of digitizing sub-bottom reflectors using the SonarWeb® software created individual comma delimited (CSV) files containing digitized points along the lane. Information in these files included the reflector name, reflector description, position (x and y) of each point, and depth (z) of each point relative to the towfish (not the actual depth). Identified sub-bottom reflectors included: the seafloor, the sand cap/dredged material interface, potential sand cap layers, and the possible dredged material/ambient sediment interface. Sporadic data gaps typically existed in these digitized files where the sub-bottom horizon could not be clearly distinguished and digitized.

Upon completion of the sub-bottom reflector processing in SonarWeb®, the data were sorted into individual comma delimited files according to reflector type to facilitate Geographic Information System (GIS) processing. Although the depth of a reflector is the distance from the towfish and not the actual depth, the thickness of sediment layers (i.e., cap material) could still be measured. The distance (depth) from the seafloor reflector to the cap interface reflector was measured to obtain a cap thickness. This process was completed using the ArcInfo® Grid module to generate a gridded data model for each surface based on the data set and a user-defined grid cell size. A surface model was created for the seafloor reflector data set and the cap interface reflector data set. The difference between these surfaces was used to generate a calculated cap thickness map. The surface model of cap thickness was then imported into ArcView® for additional analysis and review, and to generate graphic products incorporating some of the other survey datasets.

In former sub-bottom surveys over both the 1993 and 1997 Mounds, the speed of sound in the cap material was estimated in order to better calibrate the acoustic sub-bottom data (SAIC 1994, SAIC 1998a). In these previous surveys, an estimate of 1711 m/s was used for the speed of sound when post-processing this data. An increase in the assumed speed of sound up to 1711 m/s leads to an apparent increase in the cap thickness of 14% above the thickness values indicated when an assumed speed of sound of 1500 m/s is used. When this 14% increase was applied to the 2002 sub-bottom results, greater differences were noted between the acoustic cap thickness values and the coring cap thickness results. Because it provided better overall agreement with the coring results and a more conservative estimate of cap thickness, an assumed speed of sound of 1500 m/s was used for generating the final acoustic cap thickness values.

2.4.3 Side-Scan Sonar Data Processing and Analysis

Though not specified as a technical component of this contract, the side-scan sonar data were acquired during the SIS-1000 sub-bottom profiling operations. During the survey, the data from each survey lane were saved into a separate file to facilitate post-processing. During post-processing, each north-south survey lane was re-played within SonarWeb®, water column and time varied gain (TVG) adjustments were made, and then the data were merged together using the SonarWeb® mosaic utility. After the mosaic was completed, it was saved and exported as a geo-referenced Tagged Image File Format (TIFF) file. The geo-referenced TIFF of the final mosaic was then imported into a GIS for spatial analysis.

2.5 REMOTS Sediment-Profile and Sediment Plan View Imaging

2.5.1 Sampling Design and Field Methods

A total of 100 REMOTS sediment-profile imaging stations were occupied during the June 2002 postcap survey of the 1997 Category II Mound. Ninety (90) of the stations were located on and adjacent to the 1997 Category II Mound and 10 stations were located within the nearby South Reference Area (Tables 2.5-1 and 2.5-2; Figures 1.2-1 and 2.5-1). The South Reference Area was centered at 40°20.130′ N, 73°52.170′ W. The June 2002 station locations were arranged in a series of radial transects centered at the 1997 Category II Mound and extending in all directions.

The 90 REMOTS stations were spaced 100 m apart along the radial transects and were distributed as follows (Figure 2.5-1):

1) Roughly 22 of the stations comprising the west (W), west-southwest (WSW), southwest (SW), and the south-southwest (SSW) transects occurred within or near the boundary of the 1993 Dioxin Capping Monitoring Project.

2) The outer stations of the northwest (NW), north (N) and northeast (NE) transects were located on or near several former disposal mounds located in the mid-section of the former MDS.

3) The east (E) and east-southeast (ESE) transects included both the southeast corner of the former MDS and areas up to 200 m to the east of the MDS boundaries.

During all survey operations, at least two replicate sediment-profile images and one plan view image were collected at each station. Color slide film was used and developed at the end of each field day to verify proper equipment operation and image acquisition.

2.5.2 REMOTS Sediment-Profile Image Acquisition

REMOTS sediment-profile imaging is a formal and standardized technique for sediment-profile imaging and analysis (Rhoads and Germano 1982; 1986). A Benthos Model 3731 Sediment-Profile Camera (Benthos, Inc., North Falmouth, MA) was used in this study (Figure 2.5-2). The camera is designed to obtain in situ profile images of the top (20 cm) of seafloor sediment. Functioning like an inverted periscope, the camera consists of a wedge-shaped prism with a front face-plate and a back mirror mounted at a 45-degree angle to reflect the profile of the sediment-water interface facing the camera. The prism is filled with distilled water, the assembly contains an internal strobe used to illuminate the images, and a 35-mm camera is mounted horizontally on top of the prism. The prism assembly is moved up and down into the sediments by producing tension or slack on the winch wire. Tension on the wire keeps the prism in the up position, out of the sediment.

The camera frame is lowered to the seafloor at a rate of approximately 1 m/sec (Figure 2.5-2). When the frame settles onto the seafloor, slack on the winch wire allows the prism to penetrate the seafloor vertically. A passive hydraulic piston ensures that the prism enters the bottom slowly (approximately 6 cm/sec) and does not disturb the sediment-water interface. As the prism starts to penetrate the seafloor, a trigger activates a 13-second time delay on the shutter release to allow maximum penetration before a photo is taken.

Table 2.5-1.
Coordinates of REMOTS Stations
within the 1997 Category II Capping Project Area (NAD 83).
Shading indicates REMOTS/Benthic Grab Stations.

Station	Latitude	Longitude	Northing	Easting	Station	Latitude	Longitude	Northing	Easting
N0	40.3732	73.8410	75284	1028554	W300	40.3710	73.8454	74477	1027326
N100	40.3741	73.8410	75612	1028553	W400	40.3710	73.8466	74477	1027000
N200	40.3750	73.8410	75940	1028553	W500	40.3710	73.8478	74476	1026672
N300	40.3759	73.8410	76268	1028552	W600	40.3710	73.8489	74475	1026346
N400	40.3768	73.8410	76596	1028551	W700	40.3710	73.8501	74475	1026019
N500	40.3777	73.8410	76924	1028551	NW0	40.3730	73.8431	75211	1027969
NE0	40.3730	73.8388	75213	1029167	NW100	40.3737	73.8438	75465	1027762
NE100	40.3737	73.8381	75468	1029373	NW200	40.3744	73.8446	75720	1027558
NE200	40.3744	73.8373	75724	1029576	NW300	40.3751	73.8453	75974	1027352
NE300	40.3751	73.8366	75979	1029781	NW400	40.3758	73.8461	76229	1027145
NE400	40.3758	73.8359	76234	1029987	NW500	40.3765	73.8468	76484	1026941
NE500	40.3765	73.8351	76490	1030190	NNE0	40.3745	73.8392	75752	1029066
E0	40.3710	73.8400	74480	1028834	NNE100	40.3753	73.8387	76054	1029190
E100	40.3710	73.8388	74480	1029160	NNE200	40.3761	73.8383	76357	1029315
E200	40.3710	73.8377	74481	1029486	NNE300	40.3770	73.8378	76663	1029437
E300	40.3710	73.8365	74482	1029812	ENE0	40.3734	73.8360	75342	1029941
E400	40.3710	73.8353	74482	1030138	ENE100	40.3737	73.8349	75466	1030242
E500	40.3710	73.8341	74483	1030467	ENE200	40.3740	73.8339	75594	1030543
E600	40.3710	73.8330	74483	1030793	ENE300	40.3744	73.8328	75719	1030846
E700	40.3710	73.8318	74484	1031119	ESE0	40.3688	73.8360	73673	1029961
E800	40.3710	73.8306	74485	1031445	ESE100	40.3683	73.8350	73510	1030243
SE0	40.3690	73.8388	73748	1029170	ESE200	40.3679	73.8339	73346	1030527
SE100	40.3683	73.8381	73493	1029376	ESE300	40.3674	73.8329	73183	1030809
SE200	40.3676	73.8373	73239	1029580	ESE400	40.3670	73.8319	73019	1031094
SE300	40.3669	73.8366	72984	1029787	ESE500	40.3665	73.8309	72856	1031375
SE400	40.3662	73.8359	72730	1029994	SSE0	40.3667	73.8389	72932	1029157
SE500	40.3655	73.8351	72475	1030197	SSE100	40.3659	73.8384	72630	1029283
SE600	40.3648	73.8344	72220	1030404	SSE200	40.3651	73.8380	72328	1029409
SE700	40.3641	73.8336	71966	1030611	SSE300	40.3642	73.8375	72022	1029532
S0	40.3688	73.8410	73674	1028557	SSW0	40.3676	73.8425	73240	1028137
S100	40.3679	73.8410	73346	1028557	SSW100	40.3668	73.8430	72937	1028012
S200	40.3670	73.8410	73018	1028558	SSW200	40.3659	73.8434	72635	1027887
S300	40.3661	73.8410	72690	1028558	SSW300	40.3651	73.8439	72328	1027765
S400	40.3652	73.8410	72363	1028559	WSW0	40.3697	73.8453	73993	1027352
S500	40.3643	73.8410	72035	1028560	WSW100	40.3693	73.8464	73868	1027052
S600	40.3634	73.8410	71707	1028560	WSW200	40.3690	73.8475	73740	1026751
SW0	40.3690	73.8431	73746	1027971	WSW300	40.3686	73.8486	73616	1026447
SW100	40.3683	73.8438	73491	1027766	WNW0	40.3727	73.8453	75096	1027356
SW200	40.3676	73.8446	73235	1027563	WNW100	40.3730	73.8464	75220	1027055
SW300	40.3669	73.8453	72980	1027357	WNW200	40.3734	73.8475	75347	1026754
SW400	40.3662	73.8461	72724	1027151	WNW300	40.3737	73.8486	75470	1026450
SW500	40.3655	73.8468	72469	1026948	NNW0	40.3745	73.8428	75746	1028054
W0	40.3710	73.8419	74479	1028304	NNW100	40.3753	73.8432	76048	1027928
W100	40.3710	73.8431	74478	1027978	NNW200	40.3761	73.8437	76351	1027802
W200	40.3710	73.8442	74478	1027652	NNW300	40.3770	73.8441	76656	1027679

Table 2.5-2.
Coordinates of REMOTS Stations at the South Reference Area (NAD 83).
Shading Indicates REMOTS/Benthic Grab Stations.

Station	Latitude	Longitude	Northing	Easting
s3	40.3372	73.8711	62150	1020175
s4	40.3372	73.8670	62152	1021324
s5	40.3367	73.8700	61987	1020504
s8	40.3358	73.8700	61658	1020504
s10	40.3358	73.8676	61659	1021160
s11	40.3354	73.8711	61494	1020176
s14	40.3340	73.8711	61002	1020177
s16	40.3340	73.8694	61002	1020669
s18	40.3340	73.8682	61003	1020997
s20	40.3336	73.8670	60839	1021326

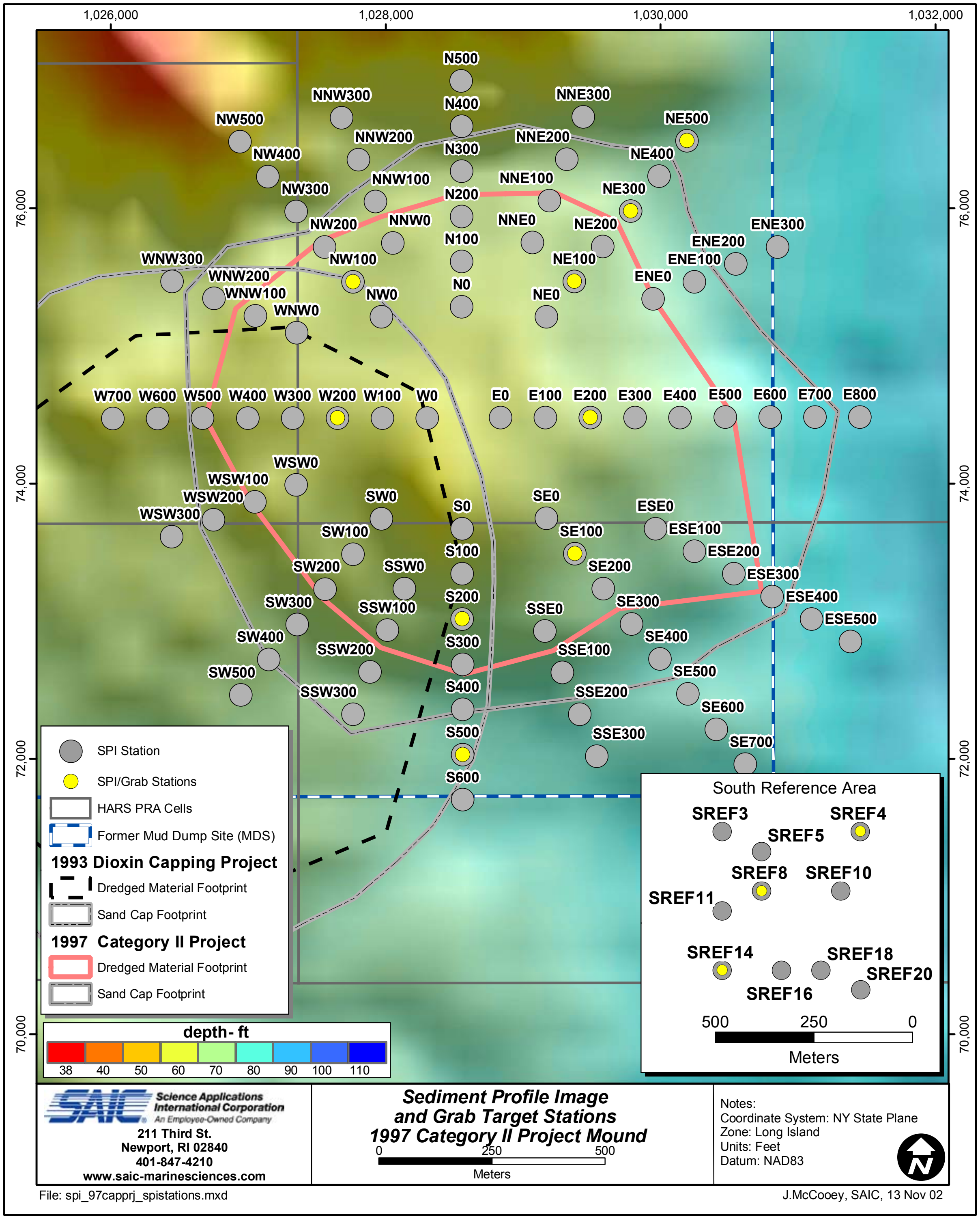


Figure 2.5-1. Location of the 2002 REMOTS and benthic grab sampling stations over the 1997 Category II Capping Project Mound Area and the nearby South Reference Area

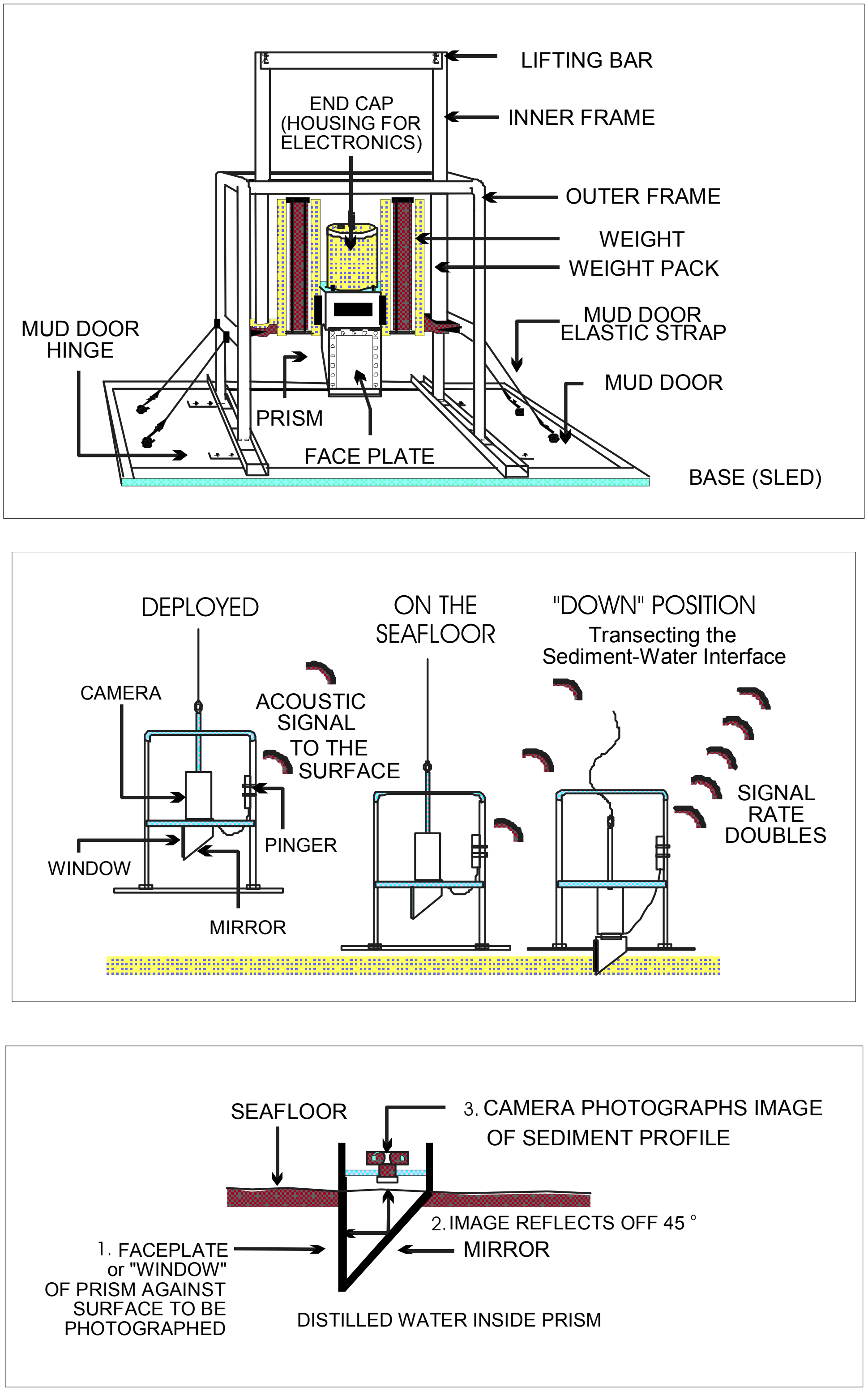


Figure 2.5-2. Schematic diagram of Benthos, Inc. Model 3731 REMOTS sediment-profile camera and sequence of operation on deployment

A Benthos Model 2216 Deep Sea Pinger is normally attached to the camera to output a 12 kHz signal once per second; upon discharge of the camera strobe, the ping rate doubles for a period of 10 seconds. By monitoring the pinger's repetition rate from the surface vessel, one can confirm that a successful image was obtained. Because the sediment photographed is directly against the face plate, turbidity of the ambient seawater does not affect image quality. When the camera is raised, a wiper blade cleans off the faceplate, the film is advanced by a motor drive, the strobe is recharged, and the camera can be lowered for another image. At least two replicate sediment-profile images were obtained at each station using color slide film (Kodak Ektachrome). The film was developed at the end of each day of field operations to verify that the equipment was operating properly and all necessary data were acquired.

2.5.3 REMOTS Sediment-Profile Image Analysis

A computerized image analysis system was used to analyze the images. The original sediment-profile images (35-mm slides) were scanned and imported digitally into the image analysis system for measurement of a suite of up to 21 standard biological and physical parameters. The data for each image were stored automatically in a centralized database and exported in various formats (data tables and reports) to be compared statistically and mapped using Arcview GIS. All measurements were reviewed (quality assurance check) before being approved for final data synthesis, statistical analyses, and interpretation. Summaries of the standard REMOTS measurement parameters presented in this report are presented below.

2.5.3.1 Sediment Type Determination

The sediment grain-size major mode and range are estimated visually from the photographs by overlaying a grain size comparator of the same scale. This comparator was prepared by photographing a series of Udden-Wentworth size classes (equal to or less than coarse silt up to granule and larger sizes) through the REMOTS sediment-profile camera. Seven grain size classes are on this comparator: >4 phi, 4 to 3 phi, 3 to 2 phi, 2 to 1 phi, 1 to 0 phi, 0 to –1 phi, and <-1 phi. Table 2.5-3 is provided to allow conversion of phi units to other commonly used grain size scales. The lower limit of optical resolution of the photographic system is about 62 microns (4 phi), allowing recognition of grain sizes equal to or greater than coarse silt. The accuracy of this method has been documented by comparing REMOTS sediment-profile image estimates with grain size statistics determined from laboratory sieve analyses.

The major modal grain size that is assigned to an image is the dominant grain size as estimated by area within the imaged sediment column. In those images that show layering of sand and mud, the dominant major mode assigned to a replicate therefore depends on how much area of the image is represented by sand versus mud. These textural assignments may or may not correspond to traditional sieve analyses depending on how closely the vertical sampling intervals are matched between the grab or core sample and the depth of the imaged sediment. Layering is noted as a comment accompanying the REMOTS sediment-profile image data file.

Table 2.5-3.
Grain Size Scales for Sediments

ASTM (Unified) Classification [1]	U.S. Std. Mesh [2]	Size in mm	PHI Size	Wentworth Classification [3]
Boulder		4096.	-12.0	
		1024.	-10.0	Boulder
	12 in (300 mm)	256.	-8.0	
		128.	-7.0	Large Cobble
Cobble		107.64	-6.75	
		90.51	-6.5	Small Cobble
	3 in. (75 mm)	76.11	-6.25	
		64.00	-6.0	
		53.82	-5.75	
		45.26	-5.5	Very Large Pebble
Coarse Gravel		38.05	-5.25	
		32.00	-5.0	
		26.91	-4.75	
		22.63	-4.5	Large Pebble
	3/4 in (19 mm)	19.03	-4.25	
		16.00	-4.0	
		13.45	-3.75	
		11.31	-3.5	Medium Pebble
Fine Gravel		9.51	-3.25	
	2.5	8.00	-3.0	
	3	6.73	-2.75	
	3.5	5.66	-2.5	Small Pebble
	4	4.76	-2.25	
	5	4.00	-2.0	
Coarse Sand	6	3.36	-1.75	
	7	2.83	-1.5	Granule
	8	2.38	-1.25	
	10	2.00	-1.0	
	12	1.68	-0.75	
	14	1.41	-0.5	Very Coarse Sand
	16	1.19	-0.25	
Medium Sand	18	1.00	0.0	
	20	0.84	0.25	
	25	0.71	0.5	Coarse Sand
	30	0.59	0.75	
	35	0.50	1.0	
	40	0.420	1.25	
	45	0.354	1.5	Medium Sand
	50	0.297	1.75	
	60	0.250	2.0	
	70	0.210	2.25	
Fine Sand	80	0.177	2.5	Fine Sand
	100	0.149	2.75	
	120	0.125	3.0	
	140	0.105	3.25	
	170	0.088	3.5	Very Fine Sand
	200	0.074	3.75	
	230	0.0625	4.0	
Fine-grained Soil:	270	0.0526	4.25	
	325	0.0442	4.5	Coarse Silt
Clay if PI ≥ 4	400	0.0372	4.75	
Silt if PI < 4		0.0312	5.0	Medium Silt
		0.0156	6.0	Fine Silt
		0.0078	7.0	Very Fine Silt
		0.0039	8.0	Coarse Clay
		0.00195	9.0	Medium Clay
		0.00098	10.0	Fine Clay
		0.00049	11.0	
		0.00024	12.0	
		0.00012	13.0	
		0.000061	14.0	

1. ASTM Standard D 2487-92. This is the ASTM version of the Unified Soil Classification System. Both systems are similar (from ASTM (1993)).
2. Note that British Standard, French, and German DIN mesh sizes and classifications are different.
3. Wentworth sizes (in inches) cited in Krumbein and Sloss (1963).

Source: U.S. Army Corps of Engineers. (1995). Engineering and Design Coastal Geology, "Engineer Manual 1110-2-1810, Washington, D.C.

2.5.3.2 Benthic Habitat Classification

Based on extensive past REMOTS sediment-profile survey experience in coastal New England, five basic benthic habitat types have been found to exist in shallow-water estuarine and open-water near shore environments: AM = Ampelisca mat, SH = shell bed, SA = hard sand bottom, HR = hard rock/gravel bottom, and UN = unconsolidated soft bottom (Table 2.5-4). Several sub-habitat types exist within these major categories (Table 2.5-4). Each of the REMOTS sediment-profile images obtained in the present study was assigned one of the habitat categories listed in Table 2.5-4.

2.5.3.3 Mud Clasts

When fine-grained, cohesive sediments are disturbed, either by physical bottom scour or faunal activity (e.g., decapod foraging), intact clumps of sediment are often scattered about the seafloor. These mud clasts can be seen at the sediment-water interface in REMOTS sediment-profile images. During image analysis, the number of clasts are counted, the diameter of a typical clast is measured, and their oxidation state is assessed. Depending on their place of origin and the depth of disturbance of the sediment column, mud clasts can be reduced or oxidized. Also, once at the sediment-water interface, these sediment clumps are subject to bottom-water oxygen levels and bottom currents. Based on laboratory microcosm observations of reduced sediments placed within an aerobic environment, oxidation of reduced surface layers by diffusion alone is quite rapid, occurring within 6–12 hours (Germano 1983). Consequently, the detection of reduced mud clasts in an obviously aerobic setting suggests a recent origin. The size and shape of mud clasts, e.g., angular versus rounded, are also considered. Mud clasts may be moved about and broken by bottom currents and/or animals (macro- or meiofauna; Germano 1983). Over time, large angular clasts become small and rounded. Overall, the abundance, distribution, oxidation state, and angularity of mud clasts are used to make inferences about the recent pattern of seafloor disturbance in an area.

2.5.3.4 Sedimentary Methane

At extreme levels of organic-loading, pore-water sulphate is depleted, and methanogenesis occurs. The process of methanogenesis is detected by the appearance of methane bubbles in the sediment column. These gas-filled voids are readily discernable in REMOTS sediment-profile images because of their irregular, generally circular aspect and glassy texture (due to the reflection of the strobe off the gas). If present, the number and total areal coverage of all methane pockets are measured.

2.5.3.5 Measurement of Dredged Material and Cap Layers

The recognition of dredged material from REMOTS sediment-profile images is usually based on the presence of anomalous sedimentary materials within an area of ambient sediment. The ability to distinguish between ambient sediment and dredged or cap material demands that the survey extend well beyond the margins of a disposal site so that an accurate characterization of the ambient bottom is obtained. The distributional anomalies may be manifested in topographic roughness, differences in grain size, sorting, shell content, optical reflectance, fabric, or sediment compaction (i.e., camera prism penetration depth). Second-order anomalies may also provide information about the effects of dredged material on the benthos and benthic processes such as bioturbation (see following sections).

Table 2.5-4.
Benthic Habitat Categories Assigned to
Sediment-Profile Images Obtained in this Study

Habitat AM: *Ampelisca* Mat
Uniformly fine-grained (i.e., silty) sediments having well-formed amphipod (*Ampelisca* spp.) tube mats at the sediment-water interface.

Habitat SH: Shell Bed
A layer of dead shells and shell fragments at the sediment surface overlying sediment ranging from hard sand to silts. Epifauna (e.g., bryozoans, tube-building polychaetes) commonly found attached to or living among the shells. Two distinct shell bed habitats:

- **SH.SI: Shell Bed over silty sediment -** shell layer overlying sediments ranging from fine sands to silts to silt-clay.
- **SH.SA: Shell Bed over sandy sediment -** shell layer overlying sediments ranging from fine to coarse sand.

Habitat SA: Hard Sand Bottom
Homogeneous hard sandy sediments, do not appear to be bioturbated, bedforms common, successional stage mostly indeterminate because of low prism penetration.

- **SA.F: Fine sand -** uniform fine sand sediments (grain size: 4 to 3 phi).
- **SA.M: Medium sand -** uniform medium sand sediments (grain size: 3 to 2 phi).
- **SA.G: Medium sand with gravel -** predominately medium to coarse sand with a minor gravel fraction.

Habitat HR: Hard Rock/Gravel Bottom
Hard bottom consisting of pebbles, cobbles and/or boulders, resulting in no or minimal penetration of the REMOTS camera prism. Some images showed pebbles overlying silty-sediments. The hard rock surfaces typically were covered with epifauna (e.g., bryozoans, sponges, tunicates).

Habitat UN: Unconsolidated Soft Bottom
Fine-grained sediments ranging from very fine sand to silt-clay, with a complete range of successional stages (I, II and III). Biogenic features were common (e.g., amphipod and polychaete tubes at the sediment surface, small surface pits and mounds, large borrow openings, and feeding voids at depth). Several sub-categories:

- **UN.SS: Fine Sand/Silty -** very fine sand mixed with silt (grain size range from 4 to 2 phi), with little or no shell hash.
- **UN.SI: Silty -** homogeneous soft silty sediments (grain size range from >4 to 3 phi), with little or no shell hash. Generally deep prism penetration.
- **UN.SF: Very Soft Mud -** very soft muddy sediments (>4 phi) of high apparent water content, methane gas bubbles present in some images, deep prism penetration.

2.5.3.6 Boundary Roughness

Small-scale boundary roughness is measured from an image with the computer image analysis system. This vertical measurement is from the highest point at the sediment-water interface to the lowest point. This measurement of vertical relief is made within a horizontal distance of 15 cm (the total width of the optical window). Because the optical window is 20 cm high, the greatest possible roughness value is 20 cm. The source of the roughness is described if known. In most cases this is either biogenic (mounds and depressions formed by bioturbation or foraging activity) or relief formed by physical processes (ripples, scour depressions, rip-ups, mud clasts, etc.).

2.5.3.7 Optical Prism Penetration Depth

The optical prism of the REMOTS sediment-profile camera penetrates the bottom under a static driving force imparted by its weight. The penetration depth into the bottom depends on the force exerted by the optical prism and the bearing strength of the sediment. If the weight of the camera prism is held constant, the change in penetration depth over a surveyed region will reflect horizontal variability in geotechnical properties of the seafloor. In this sense, the camera prism acts as a static-load penetrometer. The depth of penetration of the optical prism into the bottom can be a useful parameter, because dredged and capped materials often have different shear strengths and bearing capacities.

2.5.3.8 Infaunal Successional Stage

Determination of the infaunal successional stage applies only to soft-bottom habitats, where the REMOTS camera is able to penetrate into the sediment. In hard bottom environments (i.e., rocky substrates), camera penetration is prevented and the standard suite of REMOTS measurements cannot be made. In such instances, the infaunal successional stage is considered to be “indeterminate.” Hard bottom areas can support abundant and diverse epibenthic communities and therefore may represent habitat which is biologically productive or otherwise is of value as refuge or living space for organisms. However, the value of hard bottom habitats is not reflected in the REMOTS successional stage designation.

The mapping of infaunal successional stages is based on the theory that organism-sediment interactions in marine soft-bottom habitats follow a predictable sequence after a major seafloor perturbation (e.g., passage of a storm, disturbance by bottom trawlers, dredged material deposition, hypoxia). The theory states that primary succession results in “the predictable appearance of macrobenthic invertebrates belonging to specific functional types following a benthic disturbance. These invertebrates interact with sediment in specific ways. Because functional types are the biological units of interest, our definition does not demand a sequential appearance of particular invertebrate species or genera” (Rhoads and Boyer 1982). This theory is formally developed in Rhoads and Germano (1982) and Rhoads and Boyer (1982).

Benthic disturbance can result from natural processes, such as seafloor erosion, changes in seafloor chemistry, and predator foraging, as well as from human activities like dredged material or sewage sludge disposal, thermal effluent from power plants, bottom trawling, pollution from industrial discharge, and excessive organic loading. Evaluation of successional stages involves deducing dynamics from structure, a technique pioneered by R. G. Johnson (1972) for marine soft-bottom habitats. The application of this approach to benthic monitoring requires in situ measurements of salient structural features of organism-sediment relationships as imaged through REMOTS technology.

Pioneering assemblages (Stage I assemblages) usually consist of dense aggregations of near-surface living, tube-dwelling polychaetes (Figure 2.5-3); alternately, opportunistic bivalves may colonize in dense aggregations after a disturbance (Rhoads and Germano 1982, Santos and Simon 1980a). These functional types are usually associated with a shallow redox boundary; and bioturbation depths are shallow, particularly in the earliest stages of colonization (Figure 2.5-3). In the absence of further disturbance, these early successional assemblages are eventually replaced by infaunal deposit feeders; the start of this "infaunalization" process is designated arbitrarily as Stage II. Typical Stage II species are shallow dwelling bivalves or, as is common in New England waters, tubicolous amphipods. In studies of hypoxia-induced benthic defaunation events in Tampa Bay, Florida, Ampeliscid amphipods appeared as the second temporal dominant in two of the four recolonization cycles (Santos and Simon 1980a, 1980b).

Stage III taxa, in turn, represent high-order successional stages typically found in low-disturbance regimes. These invertebrates are infaunal, and many feed at depth in a head-down orientation. The localized feeding activity results in distinctive excavations called feeding voids (Figure 2.5-3). Diagnostic features of these feeding structures include a generally semicircular shape with a flat bottom and arched roof, and a distinct granulometric change in the sediment particles overlying the floor of the structure. This granulometric change is caused by the accumulation of coarse particles that are rejected by the animals feeding selectively on fine-grained material. Other subsurface structures, such as burrows or methane gas bubbles, do not exhibit these characteristics and therefore are quite distinguishable from these distinctive feeding structures. The bioturbational activities of these deposit-feeders are responsible for aerating the sediment. In the retrograde transition of Stage III to Stage I, it is sometimes possible to recognize the presence of relict (i.e., collapsed and inactive) feeding voids.

The end-member stages (Stages I and III) are easily recognized in REMOTS images by the presence of dense assemblages of near-surface polychaetes (Stage I) or the presence of subsurface feeding voids (Stage III; Figure 2.5-3). The presence of tubicolous amphipods at the sediment surface is indicative of Stage II. It is possible for Stage I polychaetes or Stage II tubicolous amphipods to be present at the sediment surface, while at the same time, Stage III organisms are present at depth within the sediment. In such instances, where two types of assemblages are visible in a REMOTS image, the image is designated as having either a Stage I on Stage III (I–III) or Stage II on Stage III (II–III) successional stage. Additional information on REMOTS image interpretation can be found in Rhoads and Germano (1982, 1986).

2.5.3.9 Apparent Redox Potential Discontinuity (aRPD) Depth

Aerobic near-surface marine sediments typically have higher reflectance values relative to underlying anoxic sediments. Sand also has higher optical reflectance than mud. These differences in optical reflectance are readily apparent in REMOTS sediment-profile images; the oxidized surface sediment contains particles coated with ferric hydroxide (an olive color when associated with particles), while reduced and muddy sediments below this oxygenated layer are

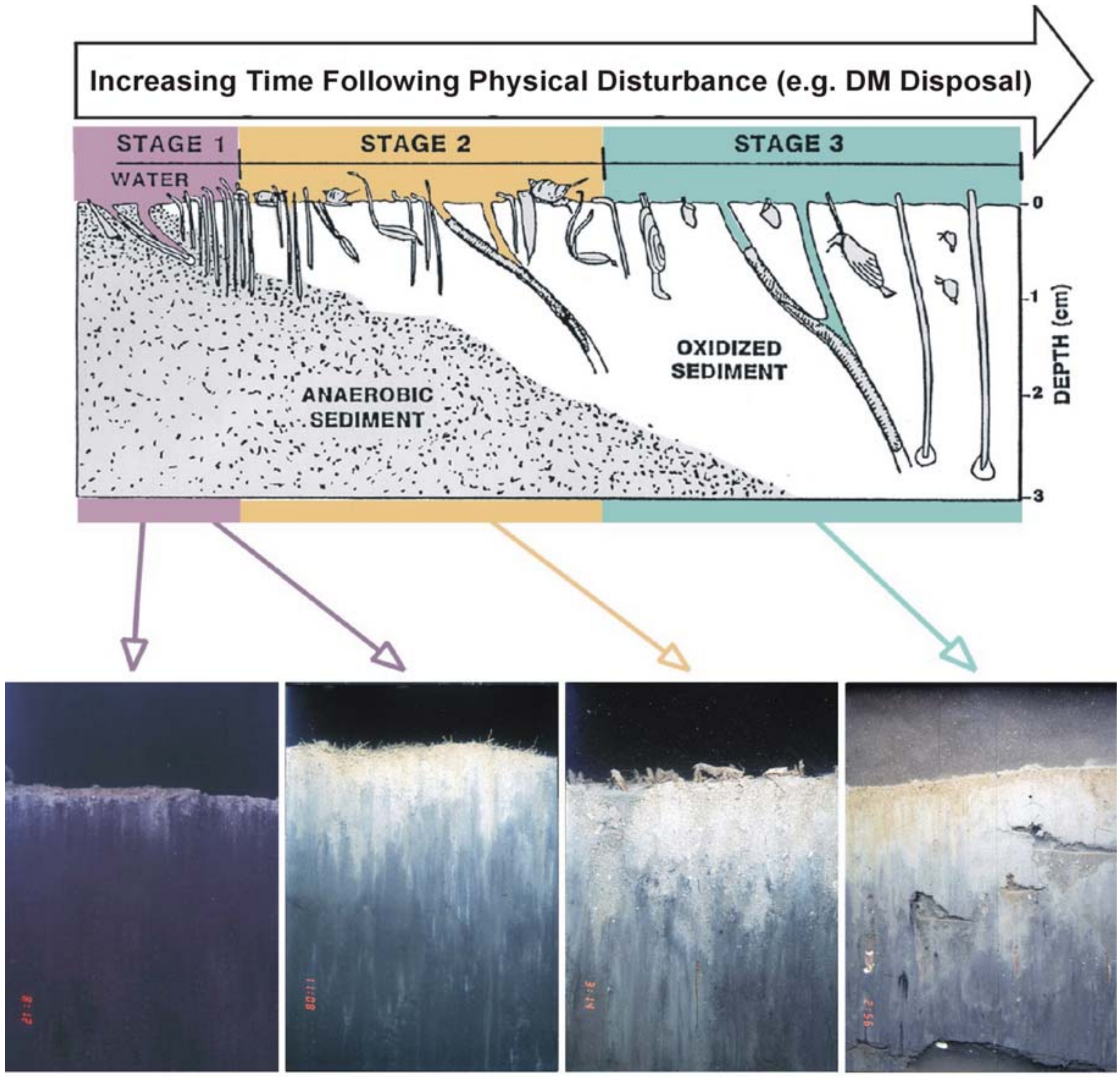


Figure 2.5-3. The drawing at the top illustrates the development of infaunal successional stages over time following a physical disturbance. The REMOTS images below the drawing provide examples of the different successional stages. Image A shows highly reduced sediment with a very shallow redox layer (contrast between light colored surface sediments and dark underlying sediments) and little evidence of infauna. Numerous small polychaete tubes are visible at the sediment surface in image B (Stage I), and the redox depth is deeper than in image A. A mixture of polychaete and amphipod tubes occurs at the sediment surface in image C (Stage II). Image D shows numerous burrow openings and feeding pockets (voids) at depth within the sediment; these are evidence of deposit-feeding, Stage III infauna. Note the aRPD is relatively deep in this image, as bioturbation by the Stage III organisms has resulted in increased sediment aeration, causing the redox horizon to be located several centimeters below the sediment-water interface.

darker, generally gray to black. The boundary between the colored ferric hydroxide surface sediment and underlying gray to black sediment is called the apparent redox potential discontinuity (aRPD).

The depth of the aRPD in the sediment column is an important time-integrator of dissolved oxygen conditions within sediment pore waters. In the absence of bioturbating organisms, this high reflectance layer (in muds) will typically reach a thickness of 2 mm (Rhoads 1974). This depth is related to the supply rate of molecular oxygen by diffusion into the bottom and the consumption of that oxygen by the sediment and associated microflora. In sediments that have very high sediment-oxygen demand, the sediment may lack a high reflectance layer even when the overlying water column is aerobic.

In the presence of bioturbating macrofauna, the thickness of the high reflectance layer may be several centimeters. The relationship between the thickness of this high reflectance layer and the presence or absence of free molecular oxygen in the associated pore waters must be made with caution. The boundary (or horizon) which separates the positive Eh region (oxidized) from the underlying negative Eh region (reduced) can only be determined accurately with microelectrodes. For this reason, we describe the optical reflectance boundary, as imaged, as the "apparent" RPD (aRPD), and it is mapped as a mean value.

The depression of the aRPD within the sediment is relatively slow in organic-rich muds (on the order of 200 to 300 micrometers per day); therefore, this parameter has a long time constant (Germano and Rhoads 1984). The rebound in the aRPD is also slow (Germano 1983). Measurable changes in the aRPD depth using the REMOTS sediment-profile image optical technique can be detected over periods of one or two months. This parameter is used effectively to document changes (or gradients), which develop over a seasonal or yearly cycle related to water temperature effects on bioturbation rates, seasonal hypoxia, sediment oxygen demand, and infaunal recruitment. In sediment-profile surveys of ocean disposal sites sampled seasonally or on an annual basis throughout the New England region performed under the DAMOS (Disposal Area Monitoring System) Program for the USACE, New England Division, SAIC repeatedly has documented a drastic reduction in aRPD depths at disposal sites immediately after dredged material disposal, followed by a progressive postdisposal aRPD deepening (barring further physical disturbance). Consequently, time-series aRPD measurements can be a critical diagnostic element in monitoring the degree of recolonization in an area by the ambient benthos.

The depth of the mean aRPD also can be affected by local erosion. The peaks of disposal mounds commonly are scoured by divergent flow over the mound. This can result in washing away of fines, development of shell or gravel lag deposits, and very thin aRPD depths. During storm periods, erosion may completely remove any evidence of the aRPD (Fredette et al. 1988).

Another important characteristic of the aRPD is the contrast in reflectance values at this boundary. This contrast is related to the interactions among the degree of organic-loading, bioturbational activity in the sediment, and the levels of bottom-water dissolved oxygen in an area. High inputs of labile organic material increase sediment oxygen demand and, subsequently, sulfate reduction rates (and the abundance of sulfide end-products). This results in more highly reduced (lower reflectance) sediments at depth and higher aRPD contrasts. In a region of generally low aRPD contrasts, images with high aRPD contrasts indicate localized sites of relatively high past inputs of organic-rich material (e.g., organic or phytoplankton detritus, dredged material, sewage sludge, etc.).

2.5.3.10 Organism-Sediment Index (OSI)

The multi-parameter REMOTS Organism-Sediment Index (OSI) has been constructed to characterize benthic habitat quality. Benthic habitat quality is defined relative to two end-member standards. The lowest value is given to those bottoms which have low or no dissolved oxygen in the overlying bottom water, no apparent macrofaunal life, and methane gas present in the sediment (see Rhoads and Germano 1982, 1986, for REMOTS criteria for these conditions). The Organism-Sediment Index (OSI) for such a condition is –10 (highly disturbed or degraded benthic habitat quality). At the other end of the scale, an aerobic bottom with a deeply depressed aRPD, evidence of a mature macrofaunal assemblage, and no apparent methane gas bubbles at depth will have an OSI value of +11 (unstressed or undisturbed benthic habitat quality).

The OSI is a sum of the subset indices shown in Table 2.5-5. The OSI is calculated automatically by SAIC software after completion of all measurements from each REMOTS photographic negative. The index has proven to be an excellent parameter for mapping disturbance gradients in an area and documenting ecosystem recovery after disturbance (Germano and Rhoads 1984, Revelas et al. 1987, Valente et al. 1992).

The OSI may be subject to seasonal changes because the mean aRPD depths vary as a result of temperature-controlled changes of bioturbation rates and sediment oxygen demand. Furthermore, the successional status of a station may change over the course of a season related to recruitment and mortality patterns or the disturbance history of the bottom. The sub-annual change in successional status is generally limited to Stage I (polychaete-dominated) and Stage II (amphipod-dominated) seres. Stage III seres tend to be maintained over periods of several years unless they are eliminated by increasing organic loading, extended periods of hypoxia, or burial by thick layers of dredged material. The recovery of Stage III seres following abatement of such events may take several years (Rhoads and Germano 1982). Stations that have low or moderate OSI values (< +6) are indicative of recently disturbed areas and tend to have greater temporal and spatial variation in benthic habitat quality than stations with higher OSI values (> +6).

2.5.4 Sediment Plan View Image Acquisition

Plan view (i.e., "downward-looking" or horizontal sediment surface plane) photographs of approximately 0.3 m^2 of the seafloor surface were obtained in conjunction with the REMOTS sediment-profile images at each station (Figure 2.5-1). The photographs were acquired with a PhotoSea 1000a 35 mm Underwater Camera System and a PhotoSea 1500s Strobe Light attached to the REMOTS sediment-profile camera frame. The plan view images were acquired immediately prior to the landing of the REMOTS sediment-profile camera frame on the seafloor, providing an undisturbed record of the surface sediments before penetration of the REMOTS sediment-profile prism. Once the camera frame was lifted above the sediments, the plan view

Table 2.5-5.
Calculation of REMOTS Organism-Sediment Index Value

A. CHOOSE ONE VALUE:

Mean aRPD Depth	Index Value
0.00 cm	0
> 0 - 0.75 cm	1
0.75 - 1.50 cm	2
1.51 - 2.25 cm	3
2.26 - 3.00 cm	4
3.01 - 3.75 cm	5
> 3.75 cm	6

B. CHOOSE ONE VALUE:

Successional Stage	Index Value
Azoic	-4
Stage I	1
Stage I to II	2
Stage II	3
Stage II to III	4
Stage III	5
Stage I on III	5
Stage II on III	5

C. CHOOSE ONE OR BOTH IF APPROPRIATE:

Chemical Parameters	Index Value
Methane Present	-2
No/Low Dissolved Oxygen**	-4

REMOTS ORGANISM-SEDIMENT INDEX = Total of above subset indices (A+B+C)

RANGE: -10 - +11

** Note: This is not based on a Winkler or polarigraphic electrode measurement. It is based on the imaged evidence of reduced, low reflectance (i.e., high oxygen demand) sediment at the sediment-water interface.

camera system automatically cycled the film and recharges the strobe in preparation for the next image. In this manner, a corresponding plan view image was usually obtained for each REMOTS sediment-profile image acquired.

2.5.5 Sediment Plan View Image Analysis

The purpose of the plan view image analysis was to supplement the more detailed and comprehensive REMOTS characterization of the seafloor. Analysis of the plan view images included screening all the replicate images acquired at each station to select one representative image for analysis. Poor water clarity, lack of contrast or water shots taken prematurely due to the camera system trigger sensitivity (sediment surface not within the focal length of the system when activated) eliminated some of the images from further consideration.

The plan view image analysis consisted of qualitative descriptions of key sediment characteristics (e.g., sediment type, bedforms and biological features) based on careful scrutiny of each chosen replicate image. Sediment descriptions were based on visual observations and therefore only the obvious presence of boulders, cobble, rock, gravel, sand and/or fines (clay and silt) were noted. Bedforms were described as being either rippled (i.e., presence of sand waves) or smooth (i.e., absence or very little evidence of sand waves) to provide an indication of physical processes (i.e., currents). Any evidence of epifaunal or infaunal organisms (i.e., fish, starfish, tubes, burrow openings, fecal mounds etc.) was also recorded.

2.6 Benthic Grab Sampling

2.6.1 Benthic Grab Sample Collection

A single sediment grab sample was obtained for benthic community analysis at 9 of the 90 REMOTS stations (10%) located over the 1997 Category II Capping Project Mound (Stations E-200, S-200, NE-100, W-200, SE-100, NW-100, NE-300, NE-500 and S-500), as well as at 3 of the 10 stations (33%) in the South Reference Area (Stations S4, S8 and S14; Figure 2.5-1). The grab sample was collected at each station using a stainless steel, 0.04 m^2 Young-modified van Veen grab sampler having a maximum penetration depth of 12 cm. Upon arrival at the target station, the grab sampler was set in an open position and lowered to the seafloor on a stainless steel winch wire. Upon reaching the bottom, the device was retrieved, causing the bucket to close and retain a surface sediment sample. The grab sampler was raised on the winch wire and placed on a stand secured to the deck of the survey vessel.

After retrieving the grab sampler, the sediment sample was determined to be acceptable or not. An acceptable grab was characterized as having relatively level, intact sediment over the entire area of the grab, and generally a sediment depth at the center of at least 7 cm. Grabs showing disturbance of the sediment surface or those containing an insufficient volume of sediment were determined to be unacceptable and rejected, resulting in re-deployment of the sampler at the station until an acceptable sample was obtained. The time of collection and geographic position of the sample were recorded both in the field logbook and by the navigation system.

Immediately following retrieval, a small subsample of surface sediment was scooped out of each acceptable grab and placed in a plastic bag for subsequent grain size analysis. The remaining sediment in the grab was transferred to a sieve having a 0.5 mm mesh size. During the sieving process, the sieve was placed on a sieve table, and a gentle flow of water was washed over the sample. Extreme care was taken to ensure that no sample was lost over the side of the sieve while agitating or washing the sample. The organisms and material (e.g., shells, wood, rock fragments, etc.) retained on the screen were placed into a labeled 1-L wide-mouth plastic container. The sample was then preserved using a 6% buffered formalin solution with Rose Bengal added to stain the organisms. Once the cap was secured, the contents were mixed by inverting the container several times. All samples were delivered by overnight mail to Barry A. Vittor and Associates, Inc. (BVA) of Mobile, AL for detailed benthic analysis (sorting, enumeration and identification to lowest practicable identification level (LPIL).

2.6.2 Benthic Sample Processing

At the BVA laboratory, each benthic sample was sorted with a dissecting microscope, and the preserved specimens identified and counted. Individual organisms were removed from each sample and placed in vials, then labeled by major taxonomic group. Taxonomists with a specialization within each major taxonomic group proceeded to identify the preserved organisms to the LPIL. Quality Assurance and Control procedures (QA/QC) associated with the benthic taxonomic analyses at BVA are described in the Quality Assurance Project Plan (SAIC 2002).

2.6.3 Benthic Data Analysis

The raw benthic community data received from the laboratory consisted of a standard species list showing the number of individuals of each taxon collected in the single grab sample at each station. Since the Van Veen grab sampled a 0.04 m^2 area of the bottom, the raw sample counts were multiplied by 25 to express abundance on a standard “per m^2” basis. To facilitate the presentation of the results, the 9 stations located either on or in the vicinity of the 1997 Category II Capping Project Mound were divided into two groups: six “mound stations” located directly on the sand cap (Stations E-200, S-200, NE-100, W-200, SE-100 and NW-100), and three “off-mound” stations located either near or outside the outer perimeter of the sand cap in areas of the HARS characterized by fine-grained, relic dredged material and/or ambient sediments (Stations NE-300, NE-500, and S-500; Figure 2.5-1). Analysis of the benthic community data included both univariate and multivariate statistical approaches, as described in the following sections.

2.6.3.1 Univariate Statistics

A number of standard univariate statistics were used to summarize the benthic community data for the three station groups (1997 Category II Mound stations, 1997 Off-Mound stations, and South Reference Area stations), including calculation of the average organism density (number of individuals per m^2) per station, average number of taxa, and the percentage breakdown of abundance by taxa. Additional analyses were performed to calculate species richness, diversity, and evenness index values for each station (sample), using the PRIMER (Plymouth Routines in Multivariate Ecological Research) software package developed at the Plymouth Marine Laboratory, UK (Clarke and Warwick 1994).

Species richness was determined using Margalef’s index (*d*), which provides a measure of the number of species (*S*) present for a given number of individuals (*N*) according to the following equation:

$$d = (S\text{-}1)/\log_2 N$$

Diversity was calculated using the Shannon-Weiner (*H'*) index:

$$H' = -\Sigma_i \, p_i \, (\log_e p_i),$$

where p_i is the proportion of the total count arising from the *ith* species.

Equitability, the evenness of the species distribution, was determined using Pielou's evenness index (*J'*):

$$J' = H' \text{ (observed)}/ \; H' \max,$$

where *H'* max is the maximum possible diversity which would be achieved if all species were equally abundant = $\log_2 (S)$. All three indices were determined using the DIVERSE routine within the PRIMER software package.

2.6.3.2 Multivariate Statistics

The univariate statistics described in the previous section each provide a measure of a single community attribute (e.g., species richness, diversity, evenness). In contrast, multivariate statistical techniques involve looking at the benthic community structure as a whole when trying to discern spatial patterns or when comparing among different samples (Clarke 1999). The term "benthic community structure" used herein refers to the concept of looking simultaneously at both the taxa that are present and their relative numbers when comparing different samples to each other.

Using the PRIMER software package, two independent but complimentary multivariate techniques were used to evaluate both the among-station and among-group patterns in overall benthic community structure: hierarchical clustering and non-metric multi-dimensional scaling (nMDS). Each of these techniques serves to classify the stations into groups having mutually-similar benthic community structure. As explained in more detail below, the techniques differ in the type of graphic display produced.

Clustering and nMDS are non-parametric methods that do not require the data to be transformed to meet underlying statistical assumptions. However, transformations do play the important role in these techniques of defining the balance between contributions from common versus rarer species in the measure of similarity among samples. In the present analysis, a decision was made to apply a square root transformation to the species abundance data in order to down-weight the contribution of the numerically dominant taxa while increasing the contribution of the rarer and/or less abundant taxa in assessing the degree of similarity among samples.

Prior to performing the clustering, the abundance values were square-root transformed, and a matrix was then constructed consisting of Bray-Curtis similarity index values (Bray and Curtis 1957) calculated between each possible pair of stations (i.e., pairwise comparisons). Hierarchical agglomerative clustering with group-average linking was then performed on this similarity matrix based on the square-root transformed abundance data (Clarke 1993). Representation of the results was by means of a tree diagram or dendrogram, with the x-axis representing the full set of samples and the y-axis representing the Bray-Curtis similarity level at which two samples or groups are considered to have fused.

Non-metric multi-dimensional scaling attempts to provide an ordination, or "map," of the stations such that distances between stations on the map reflect corresponding similarities or dissimilarities in community structure. Stations that fall in close proximity to one another on the map have similar community structure, while those that are farther apart have dissimilar structure (e.g., few taxa in common or the same taxa at different levels of abundance). Like the cluster analysis, nMDS ordination (Kruskal and Wish 1978) was performed on the matrix of Bray-Curtis similarity index values derived from the square root transformed abundance data (Clark and Green 1988; Clarke 1993). The two-dimensional nMDS plot provides a simple and compelling visual representation of the "closeness" of the benthic community structure (i.e., species composition and abundance) between any two samples or sample groups.

The ANOSIM (Analysis of Similarities) randomisation test within the PRIMER software package was used to test for statistical differences in overall benthic community structure among the three station groups (1997 Category II Mound stations, 1997 Off-Mound stations, and South Reference Area stations). The ANOSIM procedure is analogous to standard parametric Analysis of Variance (ANOVA) but is based on a non-parametric permutation procedure applied to the Bray-Curtis similarity matrix underlying the ordination of samples (see Clarke and Green 1988; Clarke 1993). This test involves calculation of a test statistic, R, which reflects the observed differences in Bray-Curtis similarities among station groups, contrasted with differences among replicates within station groups.

The ANOSIM procedure was used to provide a formal test of the null hypothesis of "no significant difference in overall benthic community structure among the three different areas represented by the three station groups (i.e., 1997 Category II Mound stations, 1997 Off-Mound stations and the South Reference Area)." The R-statistic serves to indicate the magnitude of the difference among the areas being tested and can range from 0 to 1. In general, $R>0.75$ indicates strong separation (i.e., a big difference in overall benthic community structure), $0.75>R>0.25$ indicates varying degrees of overlap but generally different community structure, and $R<0.25$ indicates little separation among the station groups being tested. The ANOSIM procedure also calculates a significance level that corresponds to the alpha level (probability of Type I error) in traditional ANOVA.

Following the ANOSIM test for among-group differences, the program SIMPER in the PRIMER package was used to identify the taxa that were the "key discriminators" in contributing to differences in benthic community structure among station groups.

2.7 Sediment Coring Survey

2.7.1 Sampling Design and Field Methods

Station locations for the vibracoring survey mirrored those historically sampled. Because these stations were initially selected to optimize sampling of the placed dredged material during previous surveys of the 1997 Category II Mound, they tend to be clustered near the center of the capped mound (Figure 2.7-1). Figure 2.7-1 shows the location of the 14 stations sampled during the coring survey, in relation to the 2002 bathymetric survey results.

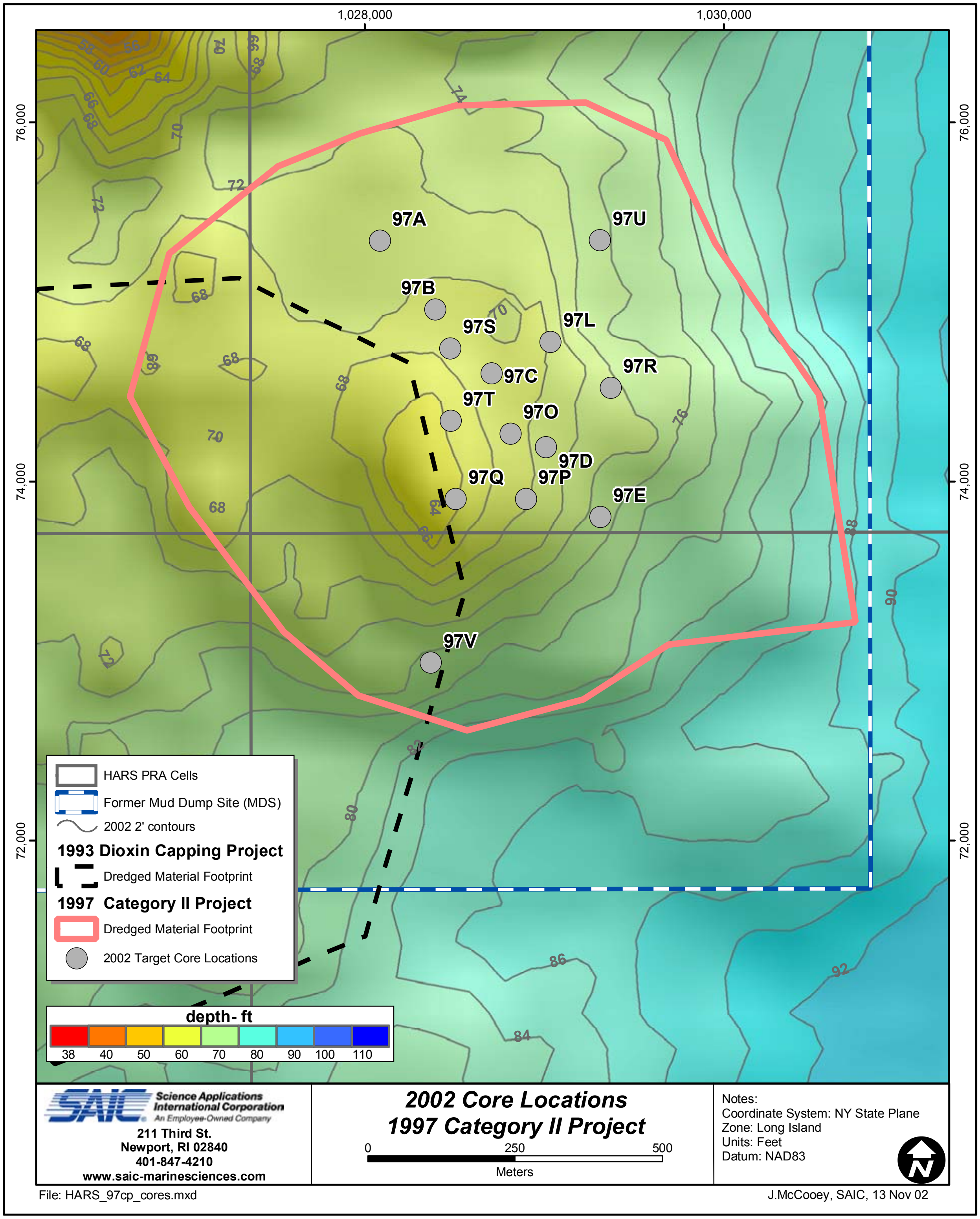


Figure 2.7-1. Vibracore station locations for the 2002 survey over the 1997 Category II Mound

The sediment coring survey was conducted aboard the NYD's M/V *Gelberman* from August 4 to 8, 2002. One sediment core was collected at each of the 14 stations shown in Figure 2.7-1. When appropriate the vessel utilized a 2-point anchoring system for core collection. Cores were cut on the survey vessel into approximately 80 cm lengths, such that the sand cap-dredged material interface remained undisturbed. Cores were labeled and stored vertically in a refrigerated unit until processed at the NYD's Caven Point laboratory facility by SAIC technicians.

An Ocean Surveys, Inc. Model 1500 vibracorer, with an internal diameter of 3.5 inches, was used to acquire the sediment core samples. This device was selected because of its demonstrated ability to acquire sediment core samples of at least 2 m in length on sand-capped mounds within the HARS. Immediately following retrieval of the vibracoring device at each station, the core liner was removed from the barrel and carefully capped and taped to prevent loss of sediment and/or water. The core was then labeled with a unique station identifier that included the month and year of the survey, the station name, number of core sections and unique identifying section labels. The cores were stored vertically in a refrigerated unit aboard the survey vessel. Cores remained refrigerated aboard the vessel and throughout the survey and analysis procedures at NYD's Caven Point facility.

2.7.2 Core Processing

The cores were transported vertically to a refrigerated unit at the NYD's Caven Point Facility where the laboratory was utilized for processing. In the laboratory, all 14 cores were split, visually described, digitally photographed, and sampled for geotechnical and sediment chemical analyses. All subsamples were kept refrigerated until shipped to the appropriate subcontracting laboratory in coolers with wet ice. Samples for sediment chemical analysis were shipped to Pace Analytical, St. Paul, Minnesota, where samples were analyzed for PCDD/PCDFs (dioxin and furans) and TOC. Geotechnical analyses included water content, bulk density, grain size, specific gravity and shear strength. SAIC technicians conducted the shear strength analysis on site while the remainder of the geotechnical analyses were conducted on samples shipped to Applied Marine Science in League City, Texas.

2.7.2.1 Core Splitting

Each core liner was scored horizontally using an SAIC designed core splitter. The core splitter is designed to score the exterior of the core liner, leaving a thin layer of Lexane liner such that the bits cut the liner and not the sediment. The thin layer of remaining liner was then cut using a precleaned utility knife, and a thin wire was used to split the sediment axially into two halves. The wire is drawn from the top of the core to the bottom to avoid potential chemical contamination of the cleaner cap sediments by the underlying project material. One half-section of the core was used for detailed visual description, digital imaging, and sediment chemical analysis sampling. The remaining core half was processed for geotechnical analyses.

2.7.2.2 Core Descriptions and Imaging

After splitting, each core was carefully examined and described in detail by SAIC personnel. Visual descriptions follow a standard SAIC modification of ASTM (American Standard Test Method) D2488 for the Description and Identification of Soils (Visual-Manual Procedure). Core descriptions were entered directly into an SAIC database and tracking system. The tracking program generated the Chain-of-Custody forms sent to the laboratories along with the subsamples. The split cores were photographed with an Olympus D500L digital camera mounted on a tripod equipped with lights. The focal distance was kept constant to easily mosaic (join) the individual images to form a continuous view of the core. The descriptions, images and sample intervals were combined within the database and used to generate a log for each core; these core logs are presented in Appendix C-1 of this report.

2.7.2.3 Core Sampling

Sediment cores were sampled for both geotechnical and chemical analyses beginning on August 7, 2002. Table 2.7-1 summarizes the type of analyses performed on each core retained by SAIC. All of the 14 cores were visually described and imaged. Geotechnical analyses included measurements of water content, bulk density, grain size (sieve and hydrometer), and specific gravity. Additionally, one shear strength measurement was conducted per core. Chemical analyses of the sediment samples included measurements of PCDD/PCDFs (i.e., dioxins and furans), TOC, and percent moisture.

The sampling plan was designed around the visual interface between the sand cap material and underlying dredged material. Samples for grain size analysis were collected from 10 cm above (sieve only) and 10 cm below (with hydrometer) this interface. Samples for bulk density, water content, and specific gravity analyses were also collected at these two horizons. Shear strength analysis was conducted 10 cm below the interface in each core. Additional bulk density and water content samples were collected at 10 cm intervals from the interface such that a total of three samples were collected from the cap while a maximum of seven samples were collected from the underlying dredged material. In some cases the core did not capture a sufficient volume of sediment to collect all of the subsamples below the interface. In these cases, samples were collected over the entire length of the core.

The core subsamples were collected from discrete 6 cm intervals at specific core depths based on the cap material and dredged material interface. Each subsample was identified by the core name and the depth at which the sample was collected, or centimeters down core. Subsamples collected from the cap material (above the interface) were identified with a (+) while samples from the dredged material unit or below the interface were identified with a (-) symbol preceding the depth at which the sample was collected. For example, Sample 97R+122 was collected from Core 97R, above the interface (+) and from a depth of 122 cm. Likewise, sample 97R-182 was collected from the same core, below the interface (-) at a depth of 182 cm.

2.7.3 Laboratory Analysis of Subsamples

2.7.3.1 Geotechnical Analyses

Grain Size

Grain size distributions of the sediment samples were determined in accordance with ASTM Method D422. Sieve sizes for sand fraction analyses included US standard sieve sizes 10, 20, 40, 60, 100, and 200, to provide coarse (1–0 phi), medium (2–1 phi), fine (3–2 phi), and very fine (4–3 phi) sand fractions, respectively. Clay and silt fractions were measured using a

Table 2.7-1.
1997 Category II Mound Core Analysis Summary

Sample ID	Visual Description	Geotechnical Analysis	Geochemical Analysis	Length (cm)	Latitude (N)	Longitude (W)
97A	X	X		288	40.3734	73.8427
97B	X	X	X	296	40.3723	73.8416
97C	X	X	X	234	40.3713	73.8405
97D	X	X		282	40.3701	73.8393
97E	X	X	X	283	40.3691	73.8384
97L	X	X		280	40.3718	73.8393
97O	X	X		286	40.3705	73.8400
97P	X	X		264	40.3693	73.8398
97Q	X	X	X	294	40.3694	73.8413
97R	X	X	X	294	40.3710	73.8381
97S	X	X		280	40.3717	73.8414
97T	X	X		292	40.3706	73.8414
97U	X	X	X	282	40.3733	73.8383
97V	X	X		291	40.3669	73.8418

hydrometer (ASTM Method D422). Size classifications were based on the Wentworth (1922) scale (Table 2.5-3). Hydrometer analysis was only conducted on samples originating below the cap/dredged material interface.

Bulk Density and Water Content

Assuming no void space due to air, the wet mass of sediment divided by the volume yields the bulk density. Bulk density for the cores was determined by pushing a cylinder of known volume into the sediment surface of the core half, leveling off each end, and then weighing it. Water content is defined as the weight of water divided by the dry weight of the sample, and is reported as a percentage. Mathematically, it is computed using the following formula:

Water Content = ((wet weight - dry weight)/ dry weight)X 100

It should be noted that in geotechnical analysis, this formulation may indicate water content values greater than 100%. For this analysis, the wet samples were weighed, dried at 110°C for 24 hours, and then reweighed according to the procedures outlined in ASTM Method D 2216. Because these samples were from the marine environment, when dried, the salt from the water was left behind, resulting in a higher dry weight (weight of solids) and consequently lower water content. Since geotechnical properties are generally based on sediments saturated with fresh water, the water contents obtained via the above formula were then normalized by an assumed salt content of 32 ppt (roughly the salinity of bottom water at the HARS), following ASTM procedures.

Specific Gravity

Specific gravity is defined as the ratio of the mass of a unit volume of material to the same volume of gas-free distilled water at a stated temperature (ASTM Method D 854), and is represented by the following formula:

G at $T_b = M_o/[M_o + (M_a – M_b)]$

where:
G = specific gravity
M_o = mass of sample of oven-dry soil, g_1
M_a = mass of pycnometer filled with water at temperature T_b, g_1
M_b = mass of pycnometer filled with water and soil at temperature T_b, g_1
T_b = temperature of the contents of the pycnometer when mass M_b was determined, ºC.

Specific gravity was measured within the dredged material layer of each of the cores, using ASTM D 854, Method A (procedure for oven dried test specimens).

Shear Strength

A laboratory vane was used to make direst measurements of the shear strength of the sediment within the cores. Vane size is determined by the softness of the material to be measured; the laboratory vane used for this material measured 12.7 X 12.7 mm. Shear strength measurements were conducted on one half of the core. A motorized vane was used to ensure consistent torque and more accurate results. Shear strength, a calculated value based on degree of spring deflection (inner) and degree of rotation of the vane (outer). Softer material requires a larger vane and soft spring, while firmer material requires a stiffer spring and smaller vane. The SAIC procedure for vane shear testing is based on ASTM D4648.

$S = M/K$ Where: S= Shear strength in kN/m^2
K= constant for the vane size used
M= Torque in N m

Vane 12.7 X 12.7 mm; K= 0.004290
Calculating M: $M = C_s\theta_f$
Where: M= is the applied torque (N mm)
C_s= is the calibration factor (N mm/degree) for the spring being used obtained from calibration data.
θ_f = is the reading indicated by the pointer on the inner scale after each test gives the relative angular deflection of the ends of the spring failure.

2.7.3.2 Sediment Chemical Analysis

Sample Collection

Sediment samples for chemical analysis were extracted from the split core at 10 and 30 cm above and below the visual cap/dredged material boundary. Six coring stations that had historical sediment chemistry data from previous surveys were selected for chemical analysis during the 2002 survey. To obtain a sufficient quantity of sediment for testing PCDD/PCDFs and TOC, samples were collected from an approximate 6-cm thick section of the core encompassing the desired sample point. Sample locations within each core are included in the core description logs in Appendix C-1.

Samples from the sand cap were removed from the core first to decrease the possibility of contamination. To further minimize contamination, only material not in contact with the core liner was sampled. Stainless steel spatulas and mixing bowls were used to remove and homogenize the sediment. Samples were placed into 125-ml precleaned glass jars. PCDD/PCDF samples were placed in amber containers due to the photosensitive nature of these compounds. TOC samples were placed in similar containers. Sampling equipment was scrubbed with Alconox ®, rinsed with distilled water, methanol and nitric acid between each sample. Samples were kept refrigerated or on ice (approximately 4° C) in coolers and in the dark, and were shipped by overnight airfreight to Pace Analytical Services, Inc. located in St. Paul, MN.

Total Organic Carbon (TOC)

TOC analyses were performed using EPA's SW-846 Method 9060 (USEPA 1997a). In this method, organic carbon is measured using a carbonaceous analyzer that converts the organic carbon in a sample to carbon dioxide (CO_2) by either catalytic combustion or wet chemical oxidation. The CO_2 formed is then either measured directly by an infrared detector or converted to methane (CH4) and measured by a flame ionization detector. The amount of CO_2 or CH4 in a sample is directly proportional to the concentration of carbonaceous material in the sample. Results in this report are expressed on a dry weight basis.

PCDD/PCDF Analyses

This section describes the methods used for sample preparation, extraction, and analysis of PCDDs/PCDFs, including QC samples. A detailed discussion of QA/QC procedures are provided in the Quality Assurance Project Plan (SAIC 2002b).

Results of QA/QC analyses are given in Section 3.0. Samples were analyzed by Pace Analytical, Inc. using EPA Method 8290 (USEPA 1997b), with modifications, such as the levels of the internal standards, recovery standards, and native spiking materials, at the levels described in EPA Method 1613 (USEPA 1994). Following extraction, sample extracts were analyzed for the following PCDDs/PCDFs using combined capillary column gas chromatography/high resolution mass spectrometry (HRGC/HRMS):

Dioxins (PCDDs):	Furans (PCDFs):
2,3,7,8-TCDD (Dioxin)	2,3,7,8-TCDF (Furan)
1,2,3,7,8-PeCDD	1,2,3,7,8-PeCDF
1,2,3,6,7,8-HxCDD	2,3,4,7,8-PeCDF
1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDF
1,2,3,6,7,9-HxCDD	1,2,3,6,7,9-HxCDF
total 2,3,7,8-HpCDD	1,2,3,4,7,8-HxCDF
OCDD	2,3,4,6,7,8-HxCDF
	1,2,3,4,6,7,8-HpCDF
	1,2,3,4,,7,8,9-HpCDF
	OCDF

The 17 PCDDs/PCDFs listed above are the compounds analyzed in Method 8290. Fourteen of these compounds are called “2,3,7,8-substituted PCDDs/PCDFs” and are the PCDDs/PCDFs believed to pose the greatest risks to human health and the environment based on structure activity relationships. The requested laboratory detection limit was 1 pptr for the tetra compounds, 5 pptr for the penta, hexa, and hepta compounds, and 10 pptr for the octa compounds.

Statistical Analysis

Descriptive statistics calculated for the geotechnical and sediment chemistry data included average, standard deviation, coefficient of variation, minimum, and maximum for each of the physical and chemical properties reported, grouped by unit (e.g., cap material and dredged material). For calculation of chemical statistics, where concentrations were below detectable limits, one-half the Limit of Detection (LOD) was used (Clarke and Warwick 1994). The coefficient of variation (CV) is a measure of the amount of variability within a set of data. It is calculated using the following formula:

Coefficient of Variation (CV) = (standard deviation/average)X100

2,3,7,8–TCDD Toxic Equivalent Concentrations

Method 8290 requires the calculation of the 2,3,7,8–TCDD Toxic Equivalent Concentration to aid in the assessment of risks associated with exposure to these compounds. A 2,3,7,8–TCDD Toxicity Equivalence Factor (TEF; Safe 1990) is assigned to each of the 2,3,7,8–substituted PCDDs/PCDFs (Table 2.7-2). A TEF relates the toxicity of that congener to an equivalent concentration of the most toxic congener, 2,3,7,8–TCDD or dioxin. TEFs were defined by a 1989 international scheme (I-TEFs/89, NATO-CCMS 1988a, 1988b) and have been adopted by EPA (USEPA 1989). TEFs are different for each congener. The concentrations of congeners detected in environmental samples are multiplied by their respective TEF, and the products are summed over all congeners, yielding a concentration with the same toxicity as an equivalent amount of 2,3,7,8–TCDD. This concentration is variously referred to as a TCDD Equivalent (TCDD-EQ), a TEQ (Toxic Equivalent), and, in this report, a Toxic Equivalent Concentration (TEC), expressed in units of ng/kg or pptr. The TECs were calculated using a value of one-half the LOD for values below detection (Clarke and Warwick 1994; McFarland et al. 1994).

Table 2.7-2.
2,3,7,8–TCDD Toxicity Equivalence Factors (TEFs) for
Polychlorinated Dibenzodioxins (Dioxin) and Dibenzofurans (Furan)

Number	Compounds	TEF (pptr)
	Dioxin Compounds	
1	2,3,7,8-TCDD	1.000
2	1,2,3,7,8-PeCDD	0.500
3	1,2,3,6,7,8-HxCDD	0.100
4	1,2,3,7,8,9-HxCDD	0.100
5	1,2,3,4,7,8-HxCDD	0.100
6	1,2,3,4,6,7,8-HpCDD	0.010
7	OCDD	0.001
8	*Total -TCDD	0
9	*Total -PeCDD	0
10	*Total -HxCDD	0
11	*Total -HpCDD	0
	Furan Compounds	
12	2,3,7,8-TCDF	0.100
13	1,2,3,7,8-PeCDF	0.050
14	2,3,4,7,8-PeCDF	0.500
15	1,2,3,6,7,8-HxCDF	0.100
16	1,2,3,7,8,9-HxCDF	0.100
17	1,2,3,4,7,8-HxCDF	0.100
18	2,3,4,6,7,8-HxCDF	0.100
19	1,2,3,4,6,7,8-HpCDF	0.010
20	1,2,3,4,7,8,9-HpCDF	0.010
21	OCDF	0.001
22	*Total -TCDF	0
23	*Total -PeCDF	0
24	*Total -HxCDF	0
25	*Total -HpCDF	0

*Excluding the 2,3,7,8-substituted congeners.
Reference: 1989 ITEFs

3.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Data quality is typically assessed in relation to specified criteria for precision, accuracy, representativeness, comparability, and completeness (PARCC). Analytical precision is expressed as the percent difference between results of replicate samples (Relative Percent Difference [RPD] or Coefficient of Variation [CV]). Analytical accuracy is evaluated quantitatively as the percent recovery of a spiked standard compound added at a known concentration to the sample before analysis. When spiked duplicates are run, the results can be expressed as an RPD to evaluate precision of the analysis of the spiked compounds. By inference, the precision of analysis of other related compounds should be similar. Laboratory accuracy also is evaluated qualitatively by evaluating the laboratory QC information on sample holding times, method blank results, tuning and mass calibration, recovery of internal standards, laboratory quality control samples, and initial and continuing calibration checks. The following section defines the various QA/QC requirements and summarizes the data quality objectives for this project.

3.1 Geotechnical Quality Control Data

All analyses were completed in accordance with the project objectives, and data were fully documented. Geotechnical data were received from Applied Marine Science in both hard copy and electronic formats. All geotechnical analyses were conducted using standard ASTM methods. As part of these methods, associated QA/QC procedures were followed by AMS. All of the samples were within the acceptable QC limits of <25% RPD. Other QC procedures in the analysis of geotechnical data include triplicate analysis of water content and grain size. These tests were preformed in the sand cap material of sample H4+182, and within the dredged material sediments of sample H3-172.

The CV was used to evaluate the precision of these data. Water content triplicates had a CV of 0.6% and 0.7% for the sand cap and dredged material layers, respectively (Table 3.1-1). For the major (≥20%) grain size components CVs ranged from 0 (fine sand in the cap) to 3.9% (silt in the DM). When the CV% is calculated for small numbers, particularly with a large range, the values tend to be skewed towards the high end. For this reason, the CV was calculated only for grain sizes comprising ≥20% of the sample. Overall, the CVs for these triplicate analyses indicate very good precision and are all acceptable.

3.2 Sediment Chemistry Quality Control Data

3.2.1 Sample Tracking Procedures and Holding Times

SAIC standard operating procedures for sample tracking and custody were followed. In preparation for the field survey, a checklist of all samples to be collected was prepared. Sample containers were precleaned, amber glass jars with Teflon-lined lids (3,000 series), and the labels were preprinted in indelible ink. Individual subsample identifiers were added to all labels in indelible ink in the field laboratory. After the subsamples were collected, the jars were sealed with waterproof tape. Label information included SAIC contact information, survey name, sample station, sample interval, type of analysis and the subcontracting laboratory contact information. All sediment chemistry samples were stored at 0–4° C. Chain-of-custody records were maintained and generated from the SAIC tracking database for all samples.

Table 3.1-1.
Results of Triplicate Analysis of Sand Cap and
Dredged Material Samples to Assess Analytical Precision

	Gravel >#4 (%)	Coarse Sand #10 (%)	Medium Sand #20-#40 (%)	Fine Sand #60-#200 (%)	Silt 0.074-0.005 mm (%)	Clay <0.005 mm (%)	Passing No. 200 <0.074 mm (%)	Water Content* (%)
Sand Cap Material Core H4+182	0.34	1.08	13.72	84.60	-	-	0.26	97
	0.36	1.04	13.77	84.51	-	-	0.32	98
	0.35	0.98	13.75	84.65	-	-	0.27	98
Average	0.35	1.03	13.75	84.59	-	-	0.28	97.67
Standard Deviation	0.01	0.05	0.03	0.07	-	-	0.03	0.58
CV (%)	**	**	**	**0.08**	-	-	**	**0.59**
Dredged Material Core H3-172	0.00	0.09	0.28	1.79	34.84	63.00	-	86
	0.00	0.10	0.28	1.89	35.24	62.50	-	87
	0.00	0.08	0.27	1.66	37.48	60.50	-	87
Average	0.00	0.09	0.28	1.78	35.85	62.00	-	86.67
Standard Deviation	0.00	0.01	0.01	0.12	1.42	1.32	-	0.58
CV (%)	**	**	**	**	**3.97**	**2.13**	-	**0.67**

CV= Coefficient of Variation (see Section X.x)

A legend for grain sizes can be found in Appendix F

* Water Content Corrected for 35 ppt salinity

**CVs were only claculated for major grain size components (>20%)

The sediment samples were collected from August 7 to 10, 2002. They were stored under refrigeration and in the dark until they could be shipped to the laboratory on August 9, 2002. The laboratory received the samples on August 10, 2002. Extraction of sediment samples was undertaken from August 22 to September 16, 2002 and the samples were analyzed from August 29 to September 24, 2002. The recommended maximum holding time for dioxin/furan samples is 30 days from sample collection to extraction, and 45 days from collection to analysis, as specified in Method 8290 (USEPA 1997b). The more recent Method 1613 states, however, that there are no demonstrated maximum holding times associated with PCDDs/PCDFs in aqueous, solid, semi-solid, tissues, or other sample matrixes, as well as extracts, and samples may be stored up to one year (USEPA 1994). Samples were held for a maximum of 40 days between collection and extraction and 48 days between collection and analysis. These samples were stored for less than the one-year recommendation of Method 1613 and the data, therefore, are considered valid with respect to sample holding time requirements.

3.2.2 Method Blanks

A laboratory method blank was prepared and analyzed with each sample batch as part of the routine laboratory quality control procedures. One blank (2101) contained a trace amount of OCDD. This level was below the calibration range of the method. Three samples associated with this blank contained OCDD at a similar level to that noted in the blank. The affected samples were flagged in the data summary sheets. In general, levels less than ten times the background are not considered statistically different from the background. All of the blanks were considered acceptable.

3.2.3 Assessment of Analytical Accuracy and Precision

Laboratory spike samples were prepared with each sample batch by extracting clean sand that had been fortified with native standards. Recoveries of spiked native compounds must fall within the range of 70 to 130% as defined by the laboratory standard operating procedure. The recoveries of the analytes from the spiked samples ranged from 80 to 116% with relative percent difference (RPD) of 0 to 17%, indicating acceptable accuracy. The OCDD in Spike Dup 2060 was recovered at an elevated level, outside of the target range and was flagged on the summary sheet; this also resulted in an elevated RPD for this analyte.

Analytical precision is expressed as the RPD between two results or the CV between three or more results. Two types of replicate samples were examined for precision analysis: laboratory spike samples, and three samples that were homogenized by the laboratory and then divided into triplicate subsamples. The triplicates were analyzed independently. The closer the numerical values of the measurements are to each other, the lower the RPD or CV. Low RPD or CV values indicate a high degree of analytical precision. The RPD between two sample results was calculated using the following equation:

RPD = (sample result - duplicate result)/(sample result + duplicate result)/2X 100

The CV values for the laboratory triplicates should equal 25% or less (USEPA 1997b). The CV for the laboratory spike samples ranged from 7.6 to 23.6%, indicating acceptable precision. Three samples (HV+100, 97Q+60, and 97R+122) were each split into three aliquots to be analyzed as triplicates. The majority of the isotopically labeled PCDDs/PCDFs fell below the detectable limit, thus precision calculations could not be made for these samples as neither dioxin or furan was detected (Table 3.2-2). Laboratory precision was found to be acceptable in that none of the samples indicated a detectable level of dioxin or furan.

3.2.4 2,3,7,8–TCDF Confirmation

Confirmation of 2,3,7,8–TCDF was performed on all samples having detected concentrations of this isomer. On the initial DB-5 capillary gas chromatographic column, other isomers can coelute with furan. Historically, problems have been associated with the separation of 2,3,7,8– TCDF and 2,3,4,7–TCDF. Therefore, these samples with concentrations over 1 pptr were re-run on a second, DB-DIOXIN column in order to confirm the presence of the 2,3,7,8–TCDF isomer. All of the samples analyzed were flagged with the detection limit based on signal-to-noise measurement and were verified by confirmation analysis.

3.2.5 Instrument Performance

Continuing calibration checks of the instrument must show a response deviation within 25% RPD for the 17 PCDD/PCDF compounds of interest and within ±35% RPD for the nine isotopically labeled PCDD/PCDF internal standards (USEPA 1997b). Daily instrument calibration checks indicated response factor deviations within these specified limits.

3.2.6 Total Organic Carbon (TOC)

A total of 40 sediment samples were analyzed for TOC according to EPA Method SW846 9060. Analyses were carried out between August 30 and September 3, 2002. Triplicates were taken from three sediment core samples, 97D-236, 97R-162, and H3-192 yielding CVs of 11%, 19%, and 0%, respectively (Table 3.2-3). Analyses of TOC are typically subject to a high degree of variation. These CV values generally indicate acceptable precision.

3.2.7 Representativeness, Completeness, and Comparability

Sample representativeness was ensured during the sampling survey by collecting a sufficient number of sediment samples from the cap (12 samples) and dredged material (12 samples) portions of the cores. All samples were collected in a uniform manner and are considered to be representative of the area sampled (see Methods).

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Comparability is based in large part on the other PARCC parameters because precision and accuracy must be known to compare one data set with another. To optimize comparability, sampling stations and sampling procedures used in the August 2002 survey were consistent with those employed in previous surveys of the HARS in which sediment chemistry samples were collected. Analytical methods and protocols were also the same for this and past surveys, and the same laboratory (Pace Analytical, Inc., formerly known as Maxim Technologies, Inc.) performed the analyses for all surveys.

For data to be considered complete, all samples must have been collected at all sampling areas specified in the original sampling plan, analyzed in full, and the values of each analysis reported. Sediment samples were collected from the specified intervals above and below the cap/dredged material interface, and all samples were analyzed. No samples were damaged during shipment. One hundred percent completeness was reported for the sample results.

Table 3.2-2.
Results of Triplicate Analysis for Dioxin and Furan
in Samples HV+100, 97Q+60, and 97R+122

Compound Name	HV+100 Average	HV+100 STDEV	HV+100 CV%	97Q+60 Average	97Q+60 STDEV	97Q+60 CV%	97R+122 Average	97R+122 STDEV	97R+122 CV%
2,3,7,8-TCDF (Furan)	0.11	0.02	17	0.10	0.00	0	0.10	0.00	3
2,3,7,8-TCDD (Dioxin)	0.14	0.03	24	0.10	0.01	6	0.10	0.00	3
1,2,3,7,8-PeCDF	0.69	0.35	51	0.49	0.00	1	0.49	0.01	2
2,3,4,7,8-PeCDF	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
1,2,3,7,8-PeCDD	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
1,2,3,4,7,8-HxCDF	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
1,2,3,6,7,8-HxCDF	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
2,3,4,6,7,8-HxCDF	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
1,2,3,7,8,9-HxCDF	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
1,2,3,4,7,8-HxCDD	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
1,2,3,6,7,8-HxCDD	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
1,2,3,7,8,9-HxCDD	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
1,2,3,4,6,7,8-HpCDF	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
1,2,3,4,7,8,9-HpCDF	0.49	0.00	1	0.49	0.00	1	0.49	0.01	2
1,2,3,4,6,7,8-HpCDD	0.49	0.00	1	1.76	2.20	125	1.05	0.99	94
OCDF	0.97	0.03	3	3.33	4.04	121	1.83	1.53	83
OCDD	8.63	2.37	27	25.80	29.71	115	11.60	11.67	101

average concentrations in pptr

Table 3.2-3.
Results of Triplicate Analysis for Total Organic Carbon

Sample ID	Results (mg/kg)	Sample ID	Results (mg/kg)	Sample ID	Results (mg/kg)
H3-192	16000	97D-236	1600	97R-162	22000
H3-192 RUN 2	16000	97D-236 RUN 2	1300	97R-162 RUN 2	19000
H3-192 RUN 3	16000	97D-236 RUN 3	1400	97R-162 RUN 3	15000
Average	**16000**	**Average**	**1433**	**Average**	**18667**
STDEV	**0**	**STDEV**	**153**	**STDEV**	**3512**
CV%	**0**	**CV%**	**11**	**CV%**	**19**

4.0 RESULTS

4.1 Bathymetric Survey

4.1.1 Bathymetric Results

As addressed in detail in the companion report (SAIC 2003a), the data quality review of the 2002 bathymetric survey results showed strong and consistent agreement throughout the entire HARS survey area. The main portion of the bathymetric survey over both the 1993 Dioxin and 1997 Category II Mound Areas was completed from 16 to 20 August 2002 and entailed a series of east-west survey lanes spaced at 100-foot intervals. Based on the gridded surface models created from the 2002 bathymetric survey, the 1997 Category II Mound appeared as circular feature on the seafloor, gently sloping from depths of around 63.5 ft in the center (near its intersection with the 1993 Dioxin Mound footprint) to depths as deep as 88 ft along its southeastern edge (Figure 4.1-1). The 1997 Category II Mound sloped away more gradually to the north and west (including the overlap area with the 1993 Dioxin Mound), with depths in these areas varying between around 64 and 74 ft. There were no significant topographic features identified within the 1997 Category II Mound Area.

4.1.2 Depth Difference Results

The depth difference grid computed over the 1997 Category II Mound was based on a postcap single-beam bathymetric survey that was conducted in April 1999. The initial depth difference comparison with this survey showed a tide artifact that resulted in strong vertical banding and computed depth differences as large as five feet in areas that should have changed little since the last survey. This problem was traced to time and range offsets that were not properly applied to the computed tidal corrections that were originally generated for the April 1999 data. After the proper tidal corrections were re-applied to this dataset, the comparison with the 2002 survey produced more representative results, though a fixed vertical offset was still evident in the data (Figure 4.1-2).

The depth difference grid based on the corrected April 1999 data indicated that there was an overall trend of deposition over the 1997 Category II Mound, averaging about 1.2 ft throughout the grid. Because there were no strong reasons (e.g., nearby disposal operations, adjacent erosion, etc.) to support the indications of uniform deposition, it seemed more likely that a slight bias in one (or both) of the surveys might have caused this consistent difference. Because of the minor variability (due to sea action, vessel draft, tidal change, speed of sound differences, etc) and resolution limits associated with any bathymetric survey data, a certain degree of difference should be expected when comparing any two bathymetric survey data sets. If the surveys were conducted properly over the identical seafloor, then the differences should be randomly scattered and average out to around zero. If the trend of the differences was skewed in either a positive or a negative direction, then that would indicate that either the seafloor had changed or that one of the surveys had a bias that affected the data.

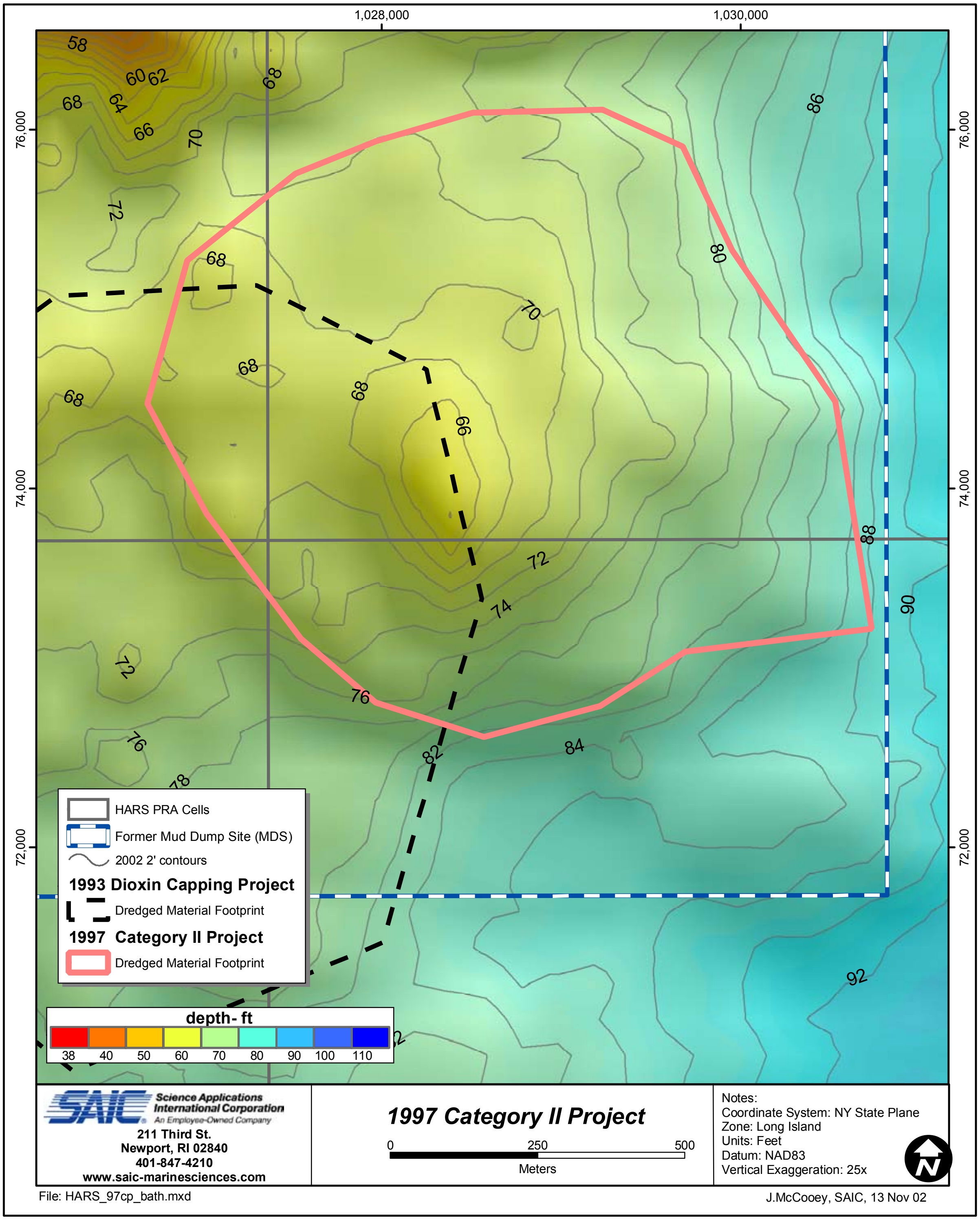


Figure 4.1-1. Color contour map with the underlying hill shading showing the results of the 2002 bathymetric survey over 1997 Category II Mound

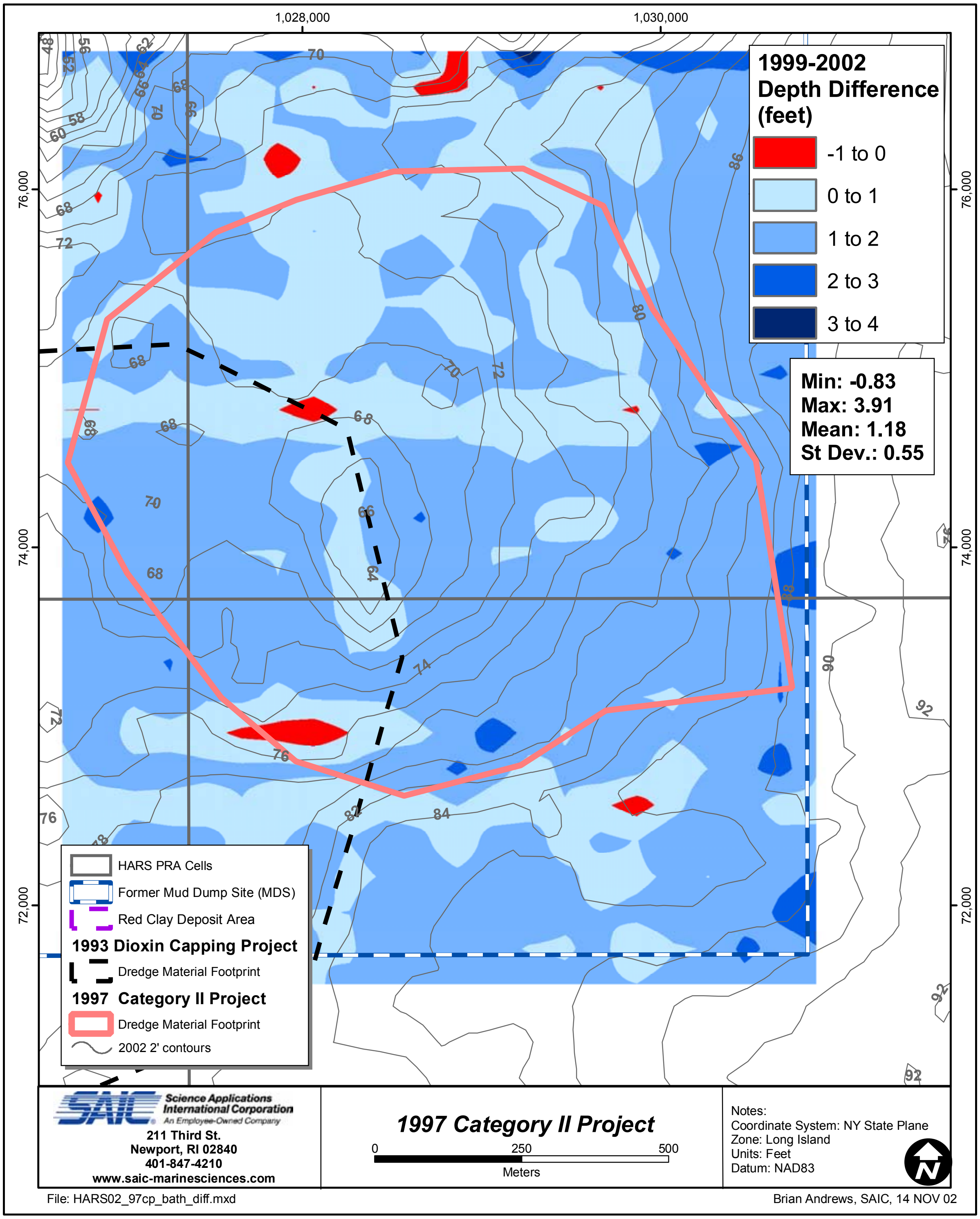


Figure 4.1-2. Bathymetric depth difference between April 1999 and August 2002 surveys of the 1997 Category II Mound Area

Because the 2002 bathymetric survey covered a large spatial area and the overall data consistency was strong throughout, it seemed more likely that a slight negative bias in the April 1999 dataset may have caused the consistent offset evident in the depth difference grid (assuming uniform deposition was unlikely throughout the mound). When a uniform offset of –1.0 ft was applied to the April 1999 dataset, then the depth difference results were more consistent with the types of random differences that would be expected when comparing two survey datasets that generally agreed well (Figure 4.1-3). This figure showed that the difference values (both positive and negative) were randomly scattered over most of the survey area.

4.2 Sub-bottom Profiling Survey

4.2.1 2002 Survey Results

Because of the data formatting problems described in Section 2.4.2 of this report, most of the sub-bottom profiling analysis was focused on the data acquired along the 15 north-south lanes that were surveyed on 6 September 2002. Because these lanes were spaced at 500-foot intervals some resolution was lost in the resulting gridded data products. In addition, although the sand cap-dredged material interface could be reliably detected throughout most of the records, there were several areas where that interface could not be clearly distinguished, resulting in sporadic along-track data gaps in the digitized sub-bottom reflector files. These data gaps were primarily associated with areas where the sand cap reflector did not provide a distinct horizon or where the seafloor surface acoustic return masked the sand cap layer (Figure 4.2-1). Because of the strength of the acoustic return signal associated with the seafloor surface and the limited resolution of the sub-bottom system, the cap layer could not be clearly distinguished when it was less than 2 ft below the seafloor surface.

Based on the gridded cap thickness model created from digitized north-south sub-bottom data, most of the area within the mound footprint appeared to be covered by around 5 to 7 feet of cap material, although the apparent acoustically detected cap thickness ranged from undetectable to over 9 ft (Figures 4.2-2 and 4.2-3). The greatest cap thickness of 7 to 9 ft occurred consistently in the western portion of the mound. In this area, the 1997 Category II Mound overlaps with the 1993 Dioxin Mound. The layering of cap material from the two projects was clearly indicated by the two distinct sub-bottom reflectors that were detected in the survey lanes passing over this area of overlap (Figure 4.2-4). Another area with apparent cap thickness greater than 8 ft was also found in the center of the 1997 Category II Mound, just outside of the overlap area with the 1993 Dioxin Mound (Figure 4.2-3).

The layer beneath the cap material reflector was presumed to be the dredged material deposit that was placed in this area just prior to the capping project. In areas near the overlap with the 1993 Dioxin Mound it was sometimes difficult to distinguish between the potential for multiple sand cap layers and the underlying dredged material deposit (Figure 4.2-5). In this area, up to four possible reflectors were revealed near the surface. Initially, the lower reflector was digitized as the underlying sand cap layer associated with the 1993 Dioxin Mound. However, because these data fell outside of the previously identified 1993 Dioxin Mound footprint and also resulted in larger than expected cap thicknesses, it was determined that this underlying reflector was most likely the interface between the pre-cap dredged material deposit and historic dredged material layer.

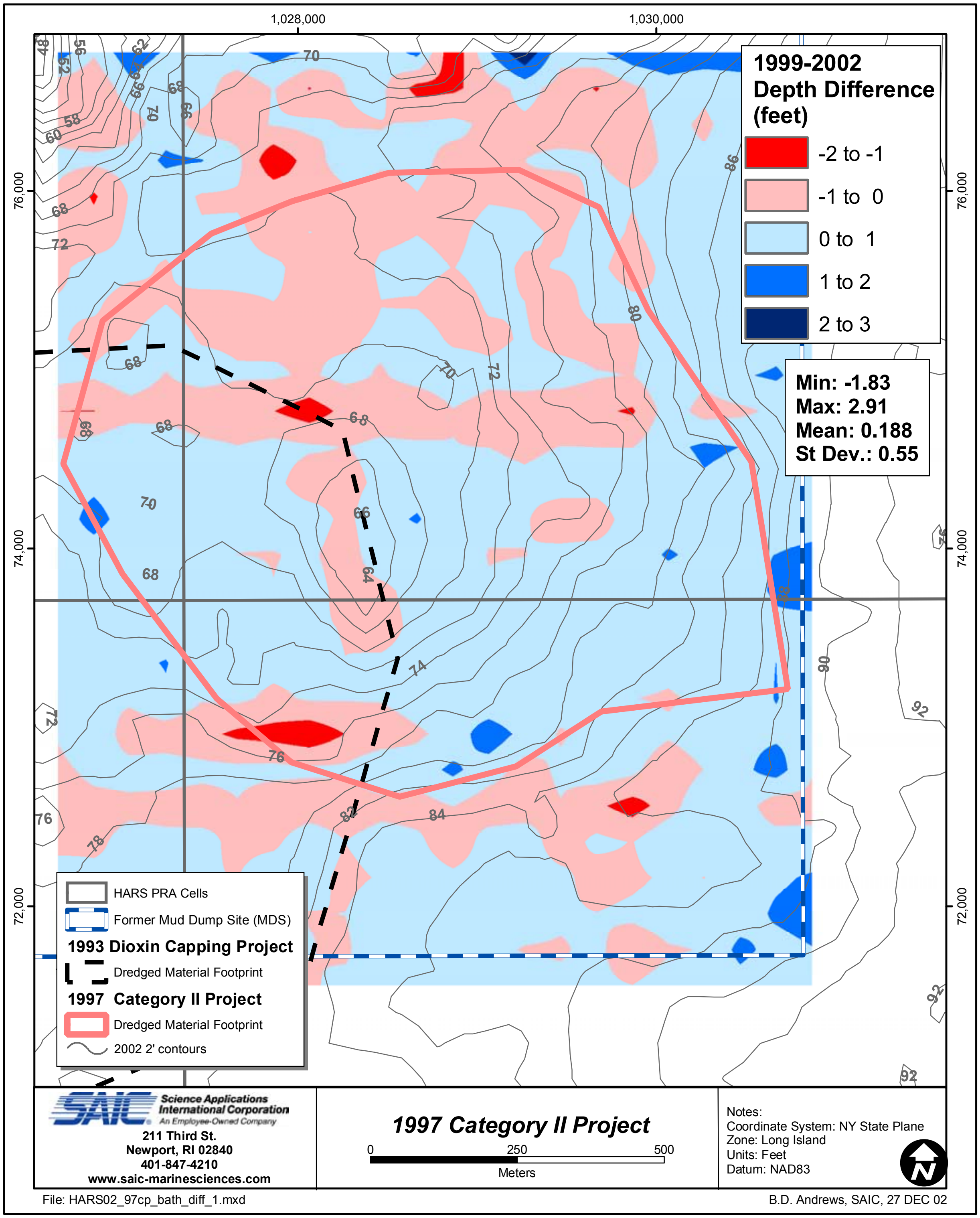


Figure 4.1-3. Bathymetric depth difference between April 1999 (with -1 ft vertical correction) and August 2002 surveys of the 1997 Category II Mound Area

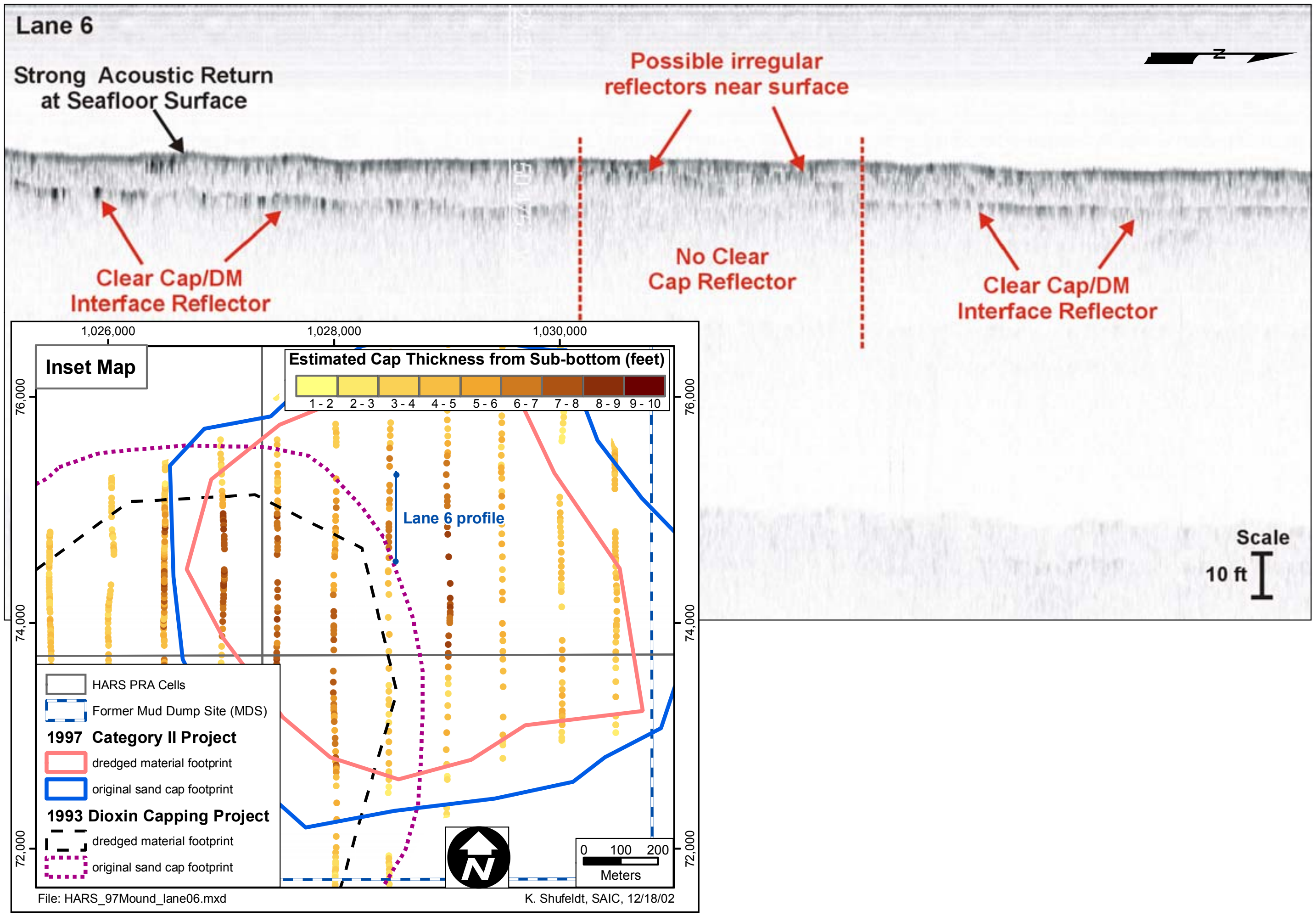


Figure 4.2-1. Estimated sand cap thickness from the 2002 sub-bottom profile survey over the 1997 Category II Mound

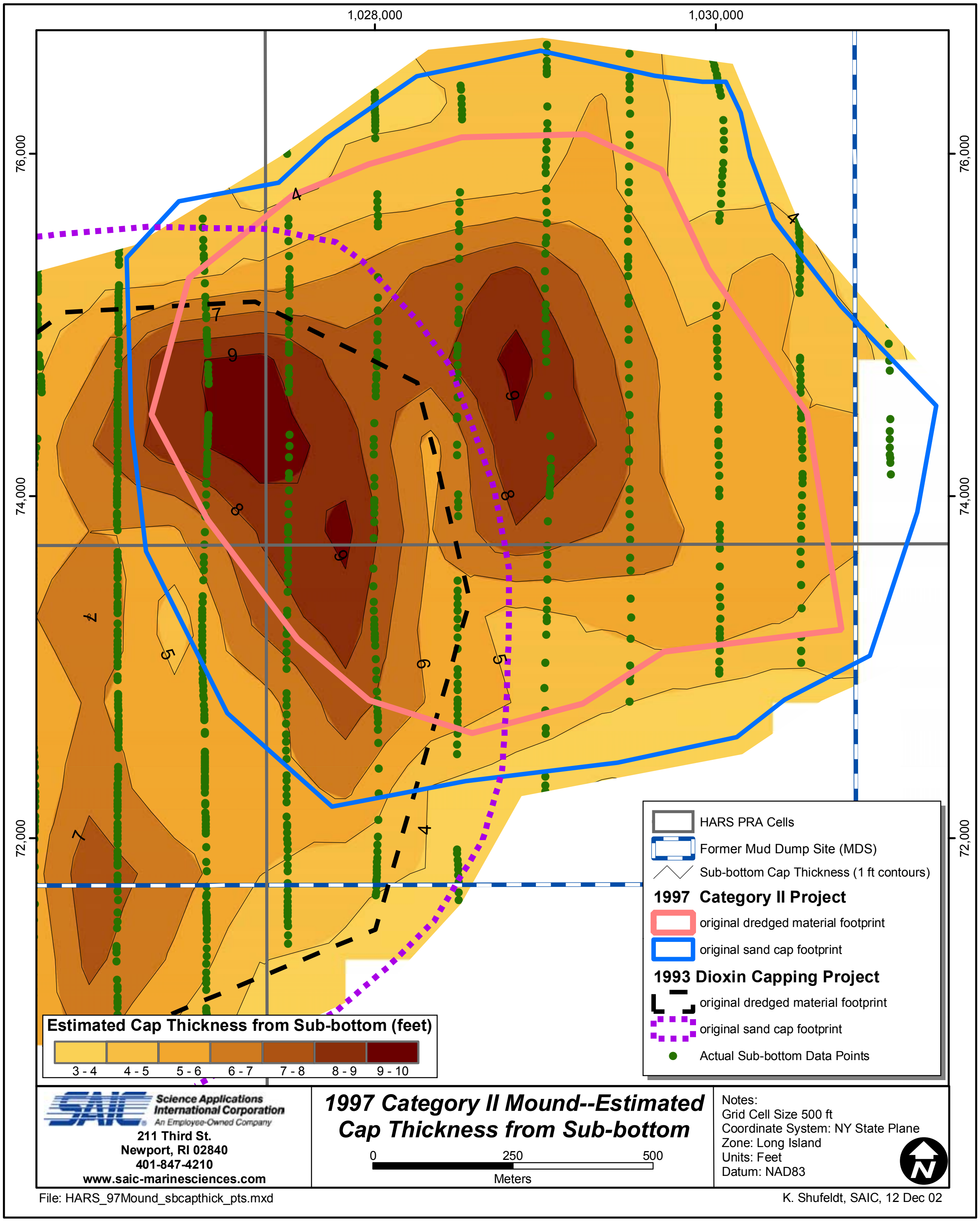


Figure 4.2-2. The survey track lines over the estimated sand cap thickness from the 2002 sub-bottom profile survey over the 1997 Category II Mound

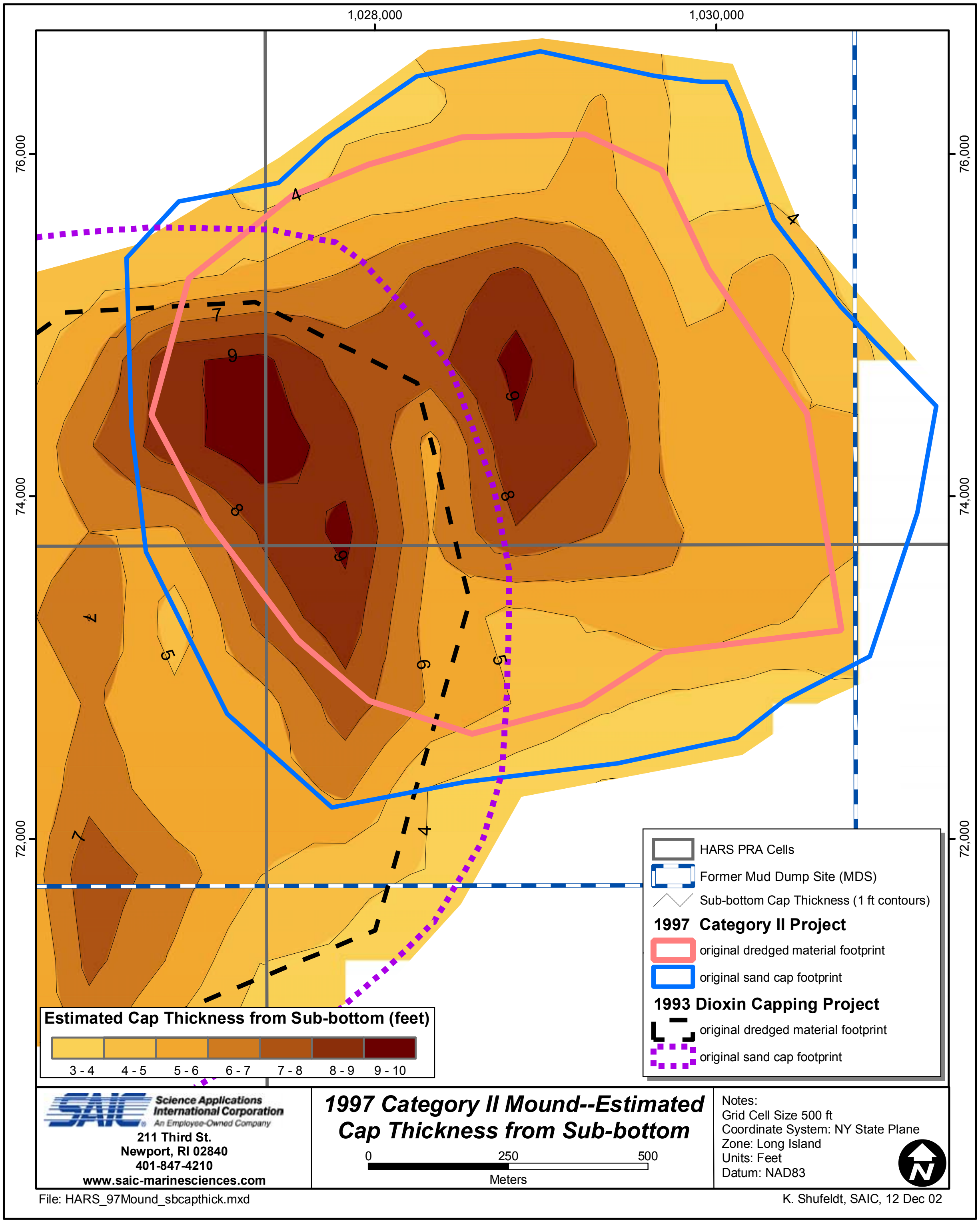


Figure 4.2-3. Estimated sand cap thickness from the 2002 sub-bottom profile survey over the 1997 Category II Mound

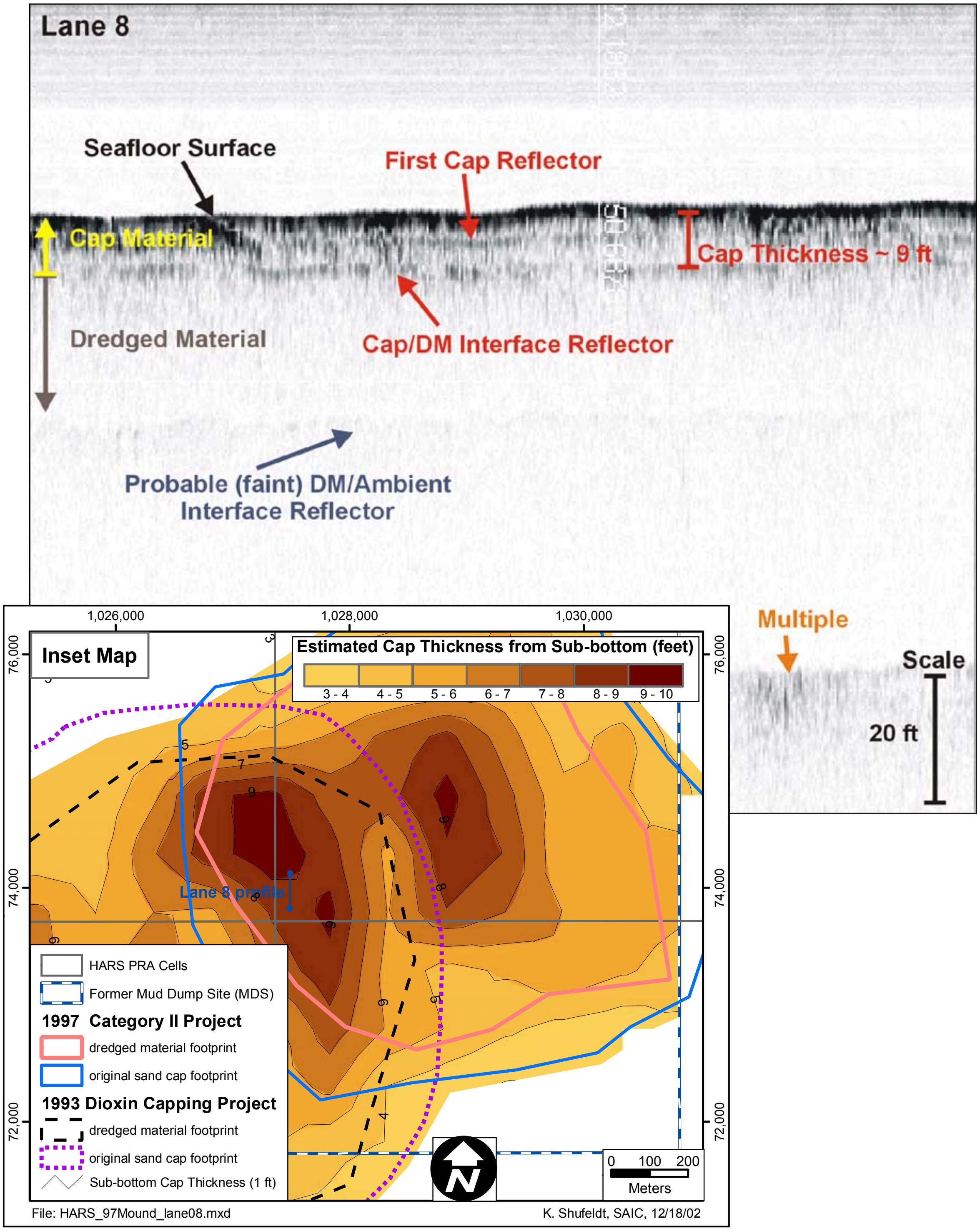


Figure 4.2-4. Representative sub-bottom profile record from a section of Lane 8 over the 1997 Category II Mound, where the 1993 and 1997 Mound Areas overlap (see inset)

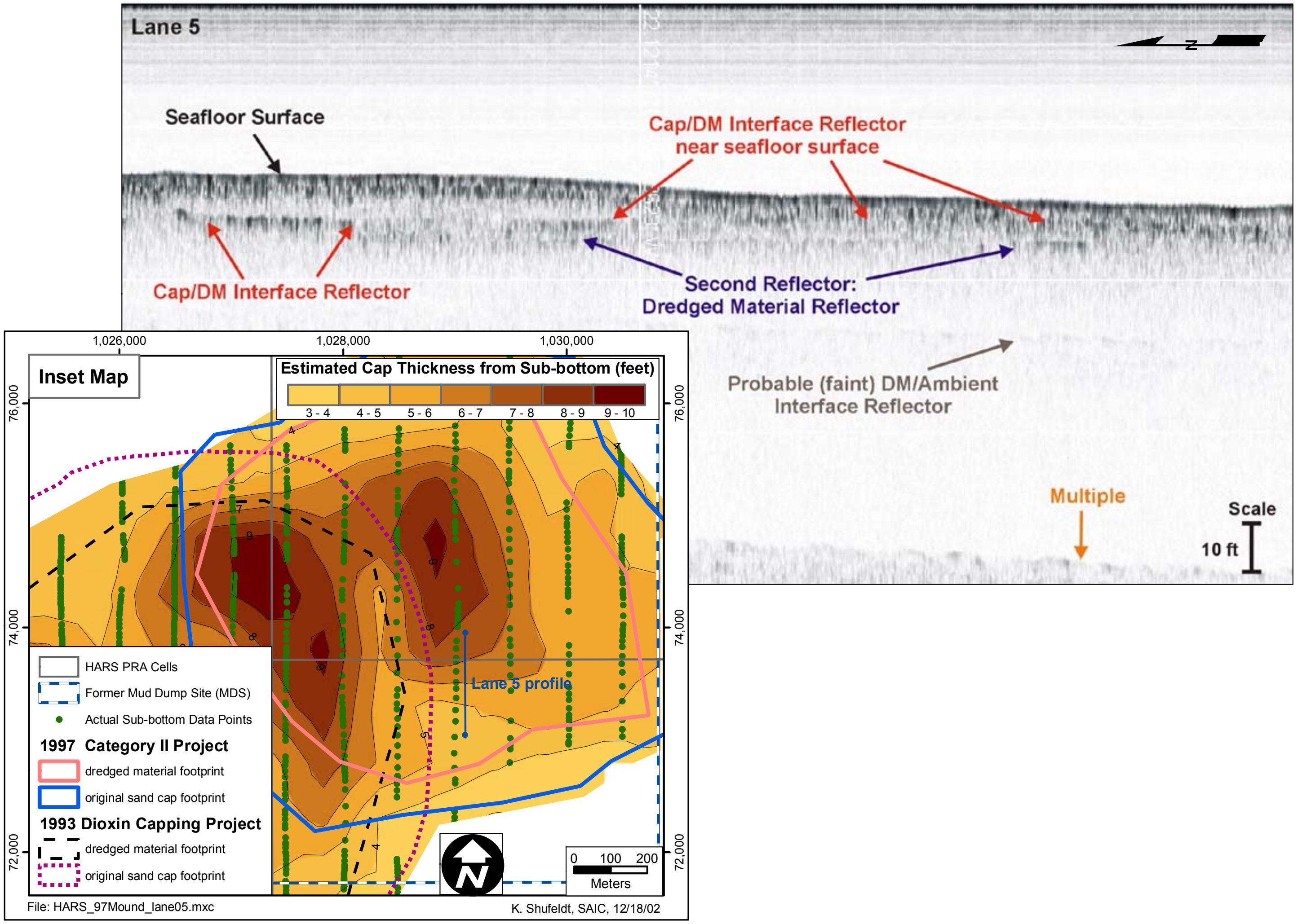


Figure 4.2-5. Representative sub-bottom profile record from a section of Lane 5 over the 1997 Category II Mound, illustrating multiple sand cap layers and underlying dredged material layers

Another distinct reflector periodically observed below the pre-cap dredged material layer was identified as the probable dredged material/ambient sediment interface or basement sand reflector (Figure 4.2-5). This reflector was usually about 20-25 ft below the seafloor surface. Because the basement reflector was only detected intermittently along each lane, a gridded model of apparent dredged material thickness could not be generated.

4.2.2 Historic Survey Comparison

The most recent sub-bottom profile survey over the 1997 Category II Mound prior to the 2002 survey was conducted in November 1997 (SAIC 1998a). This prior survey was conducted as an interim survey during the 1997 Category II Capping Project and was completed well before the completion of this project. This prior survey was oriented along an east-west direction and only covered the middle half of the mound area. The results of this prior survey indicated that the entire 1997 Category II Mound was covered by at least 3 ft (1 m) of sand, and a cap thickness of more than 6 ft was detected over some portions of the mound. As stated above, the 2002 survey results indicated an average cap thickness of 5-7 ft, with some areas over 9 ft. The apparent cap layer for the 2002 survey was thickest in the center of the dredged material footprint and in the overlap area with the 1993 Dioxin Mound. Because the 1997 sub-bottom profile survey was conducted well before the completion of the 1997 Category II Mound and did not cover the entire 1997 Category II Mound Area, it was difficult to make any meaningful comparisons between these two surveys.

The 1997 sub-bottom profile survey results over the 1997 Category II Mound also indicated a layer of pre-cap dredged material below the sand cap layer. This same layer was also evident intermittently in the 2002 sub-bottom data (Figure 4.2-5). Although it appeared that the 1997 sub-bottom profile data overlapped with the 1993 Dioxin Mound footprint, there were no results that indicated the presence of the previous sand cap deposit. It did appear that this layer might have been present in some of the raw sub-bottom data included in the previous report. The presence of a second cap reflector was clearly indicated in the 2002 survey within the area of overlap between the two mounds (Figure 4.2-4).

4.3 Side-Scan Sonar Survey

A complete 100 kHz image mosaic, representing 100% side-scan sonar bottom coverage, was created for the entire 1997 Category II Mound (Figure 4.3-1). In the mosaic, darker areas represented stronger acoustic returns (higher reflectance) and indicated harder seafloor surface materials such as gravel or other coarse sediment. The lighter areas of the mosaic represented weaker acoustic returns (lower reflectance) and indicated slightly softer seafloor surface material (silt or fine sand). Although some resolution was lost when creating the small-scale mosaic over a large area, the survey provided a useful overview of the site and enabled a broad seafloor characterization of the entire survey area.

The full area mosaic shows the majority of the mound area (mostly inside the dredged material footprint) was characterized by lower reflectance acoustic returns that were indicative of finer bottom sediments, probably comprised of sand (Figure 4.3-1). However, higher-reflectance sediment was prominent in the side-scan sonar mosaic outside the dredged material footprint. Based on its darker acoustic return, it was most likely much coarser (coarse sand, gravel, and boulders) than the sediment over the disposal mound.

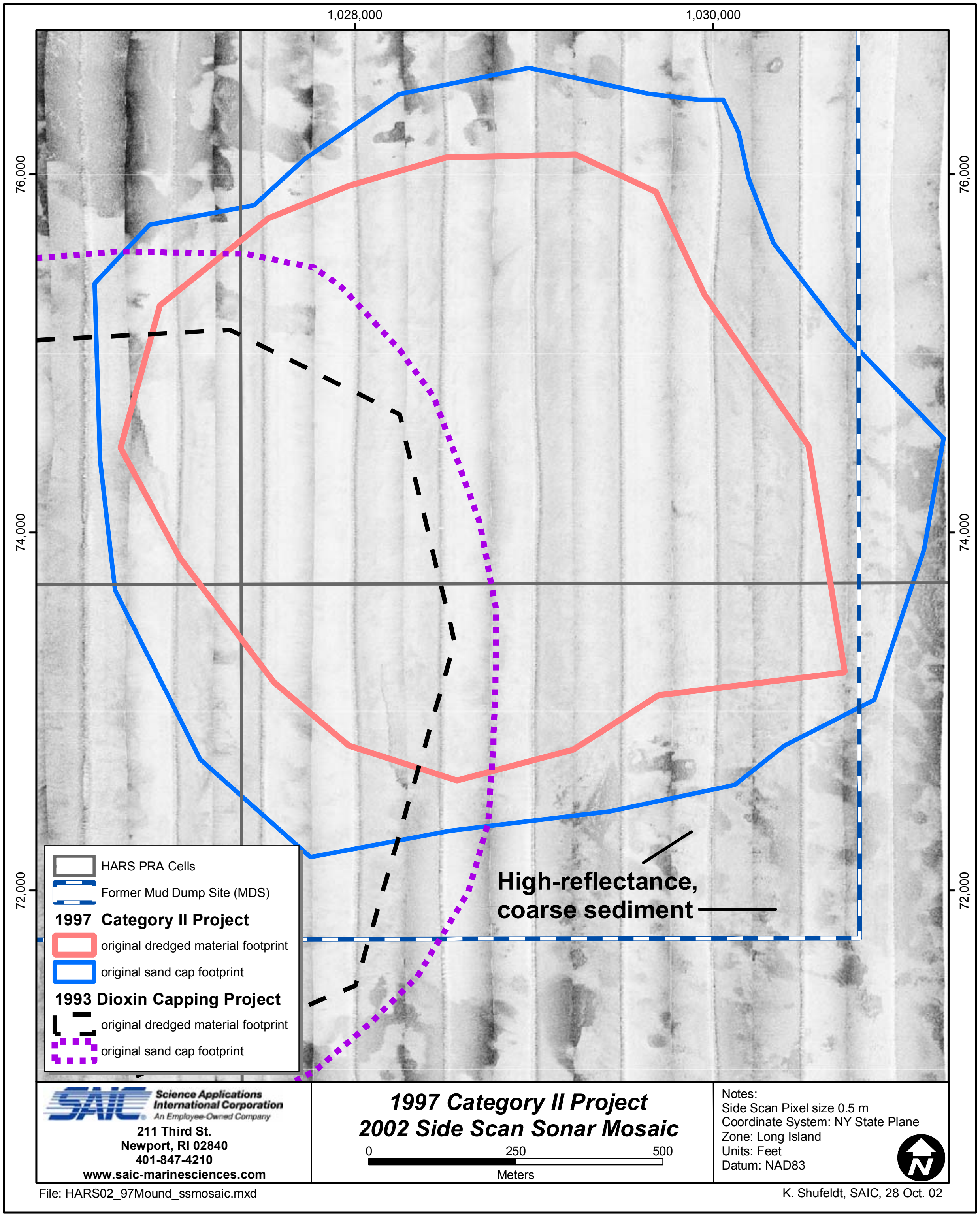


Figure 4.3-1. Side-scan sonar mosaic (100 kHz) over the 1997 Category II Mound

Along their edges, the higher-reflectance, coarser sediment deposits appeared to be partially covered by the lower-reflectance mound sediment. As shown by the bathymetry/side-scan sonar data overlay, the distinct, higher-elevation bathymetry of the disposal mound encompassed approximately the same area as the lower-reflectance areas of the side-scan mosaic (Figure 4.3-2). In the side-scan sonar mosaic no other distinct sediment types could be identified besides the finer sand (cap material) over the mound and the coarser sediment (ambient or historic dredged material) outside the mound. Dioxin-contaminated dredged material has been identified as finer grained sediment (mainly silt and clay) and should have a weaker acoustic return than any of the materials identified in the mosaic. These results suggested that the sand cap was still present over the 1997 Category II Mound.

4.4 REMOTS Sediment-Profile and Plan View Image Survey

REMOTS sediment-profile and plan view imaging results from the June 2002 survey of the 1997 Category II Mound and the South Reference Area are presented below. The complete set of REMOTS image analysis results for the surveyed areas is provided in Appendix A; these results are summarized in Tables 4.4-1 and 4.4-2.

4.4.1 Cap Material Distribution and Physical Sediment Characteristics

Analysis of the REMOTS images from the 2002 survey indicated that surface sediments at the majority of stations within the capping boundary consisted of rippled, well-sorted fine sand having a major mode of 3 to 2 phi (Table 4.4-1 and Figures 4.4-1, 4.4-2, and 4.4-3). This clean, fine sand is assumed to be the cap sand from Ambrose Channel placed systematically within the capping boundary over the period August 1997 to January 1998. However, some of the rippled fine sand found at stations to the west and southwest of the 1997 sand cap is presumed to be cap material from the overlapping 1993 Dioxin Mound. Because the sand cap material for both the 1993 and 1997 Capping Projects originated from Ambrose Channel, the cap sand observed within the 1997 Category II Mound was similar in appearance to the sand used for capping of the 1993 Dioxin Mound. In most of the REMOTS images acquired at stations on the sand cap, the depth of the sand cap layer exceeded the camera prism penetration (i.e., imaging) depth (denoted by a greater than symbol in Table 4.4-1). Therefore, cap material thickness measurements as determined by REMOTS represent conservative estimates.

With the exception of a few stations located at the outer edges of the sand cap, the surface of the cap was sufficiently thick that no underlying dredged material was observed at stations within the sand cap footprint. At a few stations within the sand cap footprint, discrete surface layers of cap material were detected over black fine-grained, relic dredged material (Figures 4.4-1 and 4.4-4). The sand-over-dredged-material stratigraphy observed at Stations ENE0, ESE300, SSW200, NNW100, and WSW200 may indicate localized areas where discrete puddles of dredged material have been covered by a thin layer of sand (Figure 4.4-1). Stations positioned outside the capping boundary generally displayed relic dredged material that exceeded the camera prism penetration; no cap material was present at these stations (for example, see Figure 4.4-5).

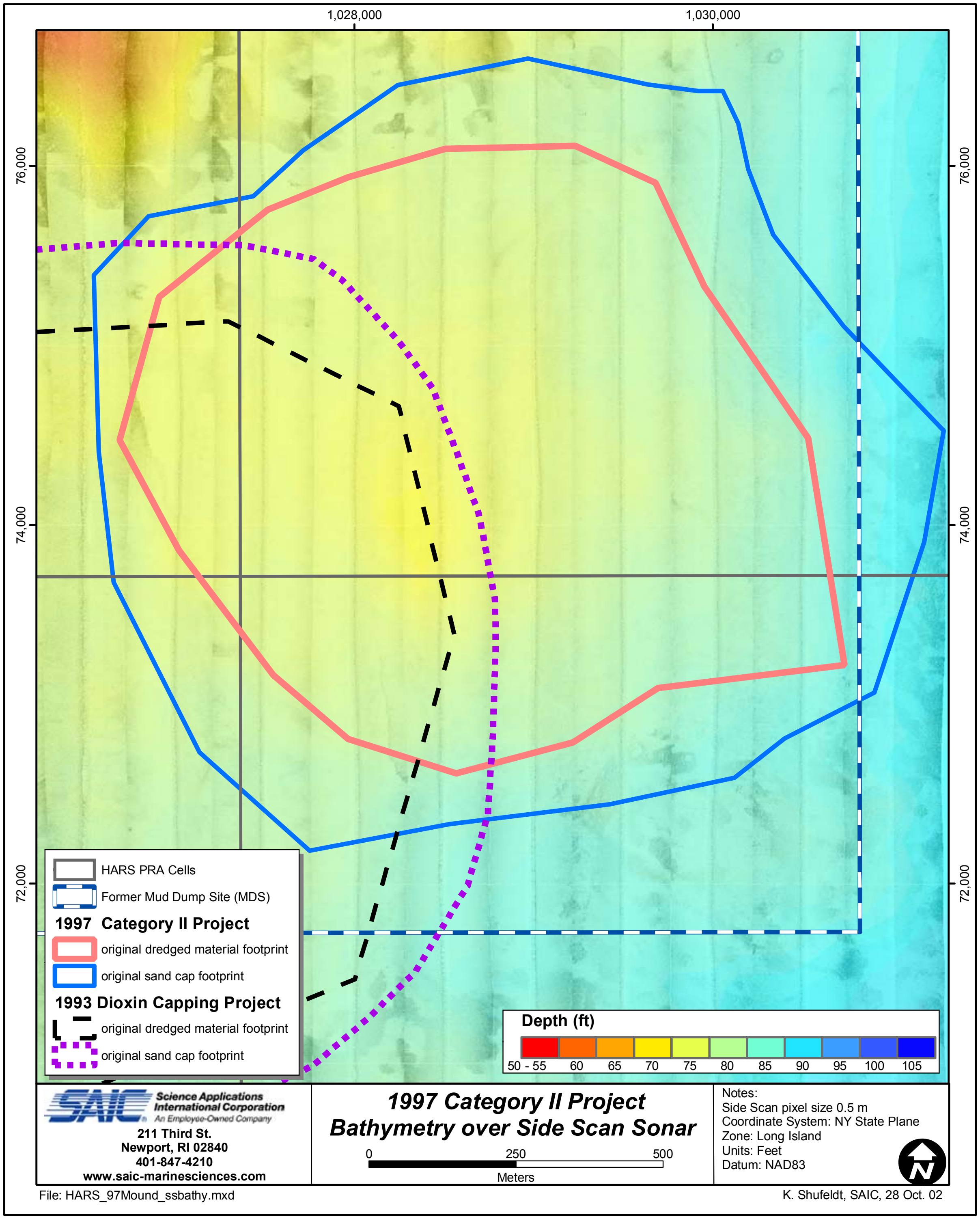


Figure 4.3-2. Composite map illustrating the 2002 bathymetric data overlaid on the side-scan sonar mosaic to demonstrate the correlation between seafloor composition and topography at the 1997 Category II Mound

Table 4.4-1.
Summary of 2002 REMOTS Results for Survey Stations over the 1997 Category II Project Area

Station	Grain Size Major Mode (# replicates)	Camera Penetration Mean (cm)	Relic Dredged Material Thickness Mean (cm)	Number Of Replicates With Dredged Material	Cap Material Thickness Mean (cm)	Boundary Roughness Mean (cm)	Benthic Habitat (# replicates)	Successional Stages Present (# replicates)	aRPD Mean (cm)	OSI Mean
E0	3 to 2 phi (2)	3.6	0.0	0	> 3.6	2.8	SA.F (2)	ST I (2)	> 3.6	6.0
E100	3 to 2 phi (2)	3.7	0.0	0	> 3.7	2.4	SA.F (2)	ST I (1), ST I to II (1)	> 3.7	7.0
E200	3 to 2 phi (2)	5.7	0.0	0	> 5.7	2.9	SA.F (2)	ST I (2)	> 5.7	7.0
E300	3 to 2 phi (2)	4.7	0.0	0	> 4.7	1.5	SA.F (2)	ST I (1), ST II (1)	> 4.7	8.0
E400	3 to 2 phi (2)	5.6	0.0	0	> 5.6	2.9	SA.F (2)	ST I (2)	5.0	7.0
E500	2 to 1 phi (2)	5.2	0.0	0	> 5.2	0.5	SA.M (2)	ST I (2)	> 4.2	7.0
E600	> 4 phi (1), 4 to 3 phi (1)	4.5	2.8	1	0.0	0.9	SA.F (1), UN.SS (1)	ST I (1), ST I to II (1)	3.0	6.0
E700	> 4 phi (2)	12.7	> 12.7	2	0.0	0.8	UN.SF (2)	ST I to II (2)	2.9	6.5
E800	> 4 phi (2)	9.9	> 9.9	2	0.0	0.5	UN.SF (1), UN.SI (1)	ST I to II (1), ST II on III (1)	2.0	7.0
ENE0	3 to 2 phi (2)	4.5	0.0	1	4.0	1.3	SA.F (2)	ST I (2)	3.6	5.5
ENE100	> 4 phi (2)	7.7	> 7.7	2	0.0	0.6	UN.SI (2)	ST II (2)	2.7	7.0
ENE200	> 4 phi (2)	16.8	> 16.8	2	0.0	0.3	UN.SF (2)	ST II on III (1), ST II to III (1)	1.7	7.0
ENE300	> 4 phi (2)	17.3	> 17.3	2	0.0	0.8	UN.SF (1), UN.SI (1)	ST II (1), ST II to III (1)	2.5	7.5
ESE0	3 to 2 phi (2)	4.2	0.0	0	> 4.2	1.3	SA.F (2)	ST I (2)	> 4.2	7.0
ESE100	3 to 2 phi (2)	5.0	0.0	0	> 5.0	0.8	SA.F (2)	ST I (2)	> 5.0	7.0
ESE200	3 to 2 phi (1), 4 to 3 phi (1)	7.0	2.3	1	> 4.6	0.8	SA.F (1), UN.SS (1)	ST I (1), ST II (1)	3.6	7.0
ESE300	3 to 2 phi (2)	4.0	0.0	0	> 4.0	1.0	SA.F (2)	ST I (2)	3.5	6.5
ESE400	4 to 3 phi (2)	5.8	> 5.8	2	0.0	0.6	UN.SS (2)	ST II (2)	2.1	6.5
ESE500	4 to 3 phi (2)	4.3	> 4.3	2	0.0	3.5	HR (2)	INDET (1), ST I (1)	2.8	5.0
N0	3 to 2 phi (2)	3.7	0.0	0	> 3.7	1.1	SA.F (2)	ST I (2)	> 3.7	6.5
N100	2 to 1 phi (1), 3 to 2 phi (1)	4.4	0.0	0	> 4.4	2.3	SA.F (1), SA.M (1)	ST I (2)	> 4.4	7.0
N200	3 to 2 phi (2)	4.6	0.0	0	> 4.6	2.6	SA.F (2)	ST I (2)	> 4.6	7.0
N300	> 4 phi (2)	10.9	> 10.9	2	0.0	0.4	UN.SI (2)	ST I (2)	2.7	5.0
N400	> 4 phi (1), 3 to 2 phi (1)	5.3	> 5.3	2	0.0	0.9	SA.F (1), UN.SI (1)	ST I (2)	2.3	4.5
N500	3 to 2 phi (2)	8.9	1.4	1	0.0	1.0	SA.F (1), UN.SS (1)	ST I (2)	4.3	6.5
NE0	3 to 2 phi (2)	3.9	0.0	0	> 3.9	1.5	SA.F (2)	ST I (2)	> 3.9	6.5
NE100	3 to 2 phi (2)	5.7	0.0	0	> 5.7	2.6	SA.F (2)	ST I (2)	> 5.7	7.0
NE200	3 to 2 phi (2)	5.5	0.0	0	> 5.5	3.6	SA.F (2)	ST I (1), ST I to II (1)	> 5.5	7.0
NE300	3 to 2 phi (2)	3.6	0.0	0	2.4	0.7	SA.F (2)	INDET (1), ST I (1)	2.8	6.0
NE400	> 4 phi (2)	15.6	> 15.6	2	0.0	0.6	UN.SF (2)	ST I (2)	0.5	0.0
NE500	> 4 phi (2)	16.9	> 16.9	2	0.0	0.6	UN.SF (2)	ST I (1), ST I to II (1)	0.7	-1.0
NNE0	2 to 1 phi (2)	5.0	0.0	0	> 5.0	1.1	SA.M (2)	ST I (1), ST II (1)	> 5.0	8.0
NNE100	3 to 2 phi (2)	4.6	0.0	0	> 4.6	2.2	SA.F (2)	ST I (2)	> 4.6	7.0
NNE200	> 4 phi (2)	8.0	> 8.0	2	0.0	0.8	UN.SI (2)	ST II (2)	2.5	7.0
NNE300	> 4 phi (2)	9.1	> 9.1	2	0.0	0.9	UN.SS (2)	ST II (1), ST II to III (1)	1.8	6.5
NNW0	3 to 2 phi (2)	5.7	0.0	0	> 5.7	1.4	SA.F (2)	ST I (2)	> 5.7	7.0
NNW100	3 to 2 phi (1), 4 to 3 phi (1)	9.8	2.9	2	6.9	1.8	SA.F (2)	ST I (2)	5.0	7.0
NNW200	> 4 phi (1), 3 to 2 phi (1)	8.0	4.0	2	3.6	1.2	SA.F (1), UN.SS (1)	ST I (2)	3.0	5.5
NNW300	2 to 1 phi (2)	4.9	> 2.3	1	0.0	1.3	SA.G (1), SA.M (1)	ST I (2)	4.3	6.5
NW0	3 to 2 phi (2)	5.1	0.0	0	> 5.1	1.7	SA.F (2)	ST I (2)	> 5.1	7.0
NW100	3 to 2 phi (2)	5.7	0.0	0	> 5.7	0.8	SA.F (2)	ST I (2)	> 5.7	7.0
NW200	3 to 2 phi (2)	5.6	0.0	0	> 5.6	1.9	SA.F (2)	ST I (2)	> 5.6	7.0
NW300	> 4 phi (1), 3 to 2 phi (1)	9.0	7.0	1	0.0	2.2	SA.F (1), UN.SF (1)	ST I (1), ST II (1)	2.6	6.0
NW400	> 4 phi (1), 4 to 3 phi (1)	11.1	> 11.1	2	0.0	2.1	HR (1), UN.SI (1)	ST I (2)	1.9	4.0
NW500	0 to -1 phi (1), 1 to 0 phi (1)	3.8	> 3.8	2	0.0	1.5	HR (2)	INDET (2)	INDET	INDET

Table 4.4-1. (continued)

Station	Grain Size Major Mode (# replicates)	Camera Penetration Mean (cm)	Relic Dredged Material Thickness Mean (cm)	Number Of Replicates With Dredged Material	Cap Material Thickness Mean (cm)	Boundary Roughness Mean (cm)	Benthic Habitat (# replicates)	Successional Stages Present (# replicates)	aRPD Mean (cm)	OSI Mean
S0	3 to 2 phi (2)	5.9	0.0	0	> 5.9	1.9	SA.F (2)	ST I (2)	> 5.9	7.0
S100	3 to 2 phi (2)	4.1	0.0	0	> 4.1	1.9	SA.F (2)	ST I (2)	> 4.1	7.0
S200	3 to 2 phi (2)	4.2	0.0	0	> 4.2	2.1	SA.F (2)	ST I (2)	> 4.2	7.0
S300	3 to 2 phi (2)	6.2	0.0	0	> 6.2	1.4	SA.F (2)	ST I (2)	4.8	7.0
S400	> 4 phi (2)	12.9	> 12.9	2	0.0	0.4	UN.SF (2)	ST II (1), ST II to III (1)	2.3	7.0
S500	> 4 phi (2)	15.4	> 15.4	2	0.0	0.5	UN.SF (2)	ST II (1), ST II to III (1)	1.0	5.5
S600	> 4 phi (2)	15.2	> 15.2	2	0.0	0.4	UN.SF (2)	ST II to III (2)	2.2	7.0
SE0	3 to 2 phi (2)	3.4	0.0	0	3.4	0.8	SA.F (2)	ST I (2)	3.4	6.0
SE100	3 to 2 phi (2)	5.0	0.0	0	> 5.0	2.1	SA.F (2)	ST I (2)	> 5.0	7.0
SE200	3 to 2 phi (2)	6.6	0.0	0	> 6.6	1.5	SA.F (2)	ST I (2)	5.0	7.0
SE300	3 to 2 phi (2)	3.8	0.0	0	> 3.8	2.2	SA.F (2)	ST I (2)	> 3.8	6.5
SE400	> 4 phi (2)	9.7	> 9.7	2	0.0	0.5	UN.SF (1), UN.SS (1)	ST I (1), ST II (1)	2.8	6.5
SE500	3 to 2 phi (2)	2.4	0.0	0	0.0	1.8	SA.F (2)	INDET (1), ST I (1)	> 3.7	6.0
SE600	0 to -1 phi (2)	3.6	0.0	0	0.0	1.0	SA.G (2)	ST I (2)	> 3.6	6.5
SE700	2 to 1 phi (1), 3 to 2 phi (1)	4.4	0.0	0	0.0	0.9	SA.F (1), SA.M (1)	ST I (1), ST II (1)	> 4.4	8.0
SSE0	3 to 2 phi (2)	5.4	0.0	0	> 5.4	1.2	SA.F (2)	ST I (2)	> 5.4	7.0
SSE100	3 to 2 phi (2)	4.9	0.0	0	0.0	1.4	SA.F (2)	ST I (2)	> 4.9	7.0
SSE200	3 to 2 phi (2)	4.6	0.0	0	0.0	1.4	SA.F (2)	ST I (2)	3.9	6.0
SSE300	2 to 1 phi (1), 4 to 3 phi (1)	3.1	> 3.1	2	0.0	1.7	SA.M (1), UN.SS (1)	INDET (1), ST I (1)	1.4	3.0
SSW0	3 to 2 phi (2)	5.5	0.0	0	> 5.5	2.7	SA.F (2)	ST I (2)	> 5.5	7.0
SSW100	3 to 2 phi (2)	3.8	0.0	0	> 3.8	2.2	SA.F (2)	ST I (2)	> 3.8	6.5
SSW200	3 to 2 phi (2)	4.9	0.7	1	4.6	2.1	SA.F (2)	ST I (2)	3.8	6.5
SSW300	3 to 2 phi (2)	5.4	0.0	0	> 5.4	2.7	SA.F (2)	ST I (2)	4.2	6.0
SW0	3 to 2 phi (2)	4.8	0.0	0	> 4.8	0.8	SA.F (2)	ST I (2)	> 4.8	7.0
SW100	3 to 2 phi (2)	4.0	0.0	0	> 4.0	2.2	SA.F (2)	ST I (2)	> 4.0	7.0
SW200	3 to 2 phi (2)	6.1	0.0	0	> 6.1	3.4	SA.F (2)	ST I (2)	4.4	7.0
SW300	3 to 2 phi (2)	3.6	0.0	0	> 3.6	1.5	SA.F (2)	ST I (2)	> 3.6	6.0
SW400	2 to 1 phi (1), 4 to 3 phi (1)	6.5	2.4	1	4.3	1.4	SA.M (1), UN.SS (1)	ST I (2)	3.3	6.0
SW500	3 to 2 phi (2)	4.1	0.0	0	> 4.1	2.1	SA.F (2)	ST I (1), ST II (1)	> 4.1	8.0
W0	3 to 2 phi (2)	4.7	0.0	0	> 4.7	1.9	SA.F (1), SA.M (1)	ST I (2)	> 4.7	7.0
W100	3 to 2 phi (2)	4.6	0.0	0	> 4.7	2.2	SA.F (2)	ST I (2)	> 4.7	7.0
W200	3 to 2 phi (2)	3.1	0.0	0	> 3.1	1.3	SA.F (2)	ST I (2)	> 3.1	5.5
W300	3 to 2 phi (2)	4.0	0.0	0	> 4.0	1.0	SA.F (2)	ST I (2)	> 4.0	6.5
W400	3 to 2 phi (2)	3.6	0.0	0	> 3.6	2.3	SA.F (2)	ST I (2)	> 3.6	6.0
W500	3 to 2 phi (2)	4.7	0.0	0	> 4.7	2.8	SA.F (2)	ST I (2)	> 4.7	7.0
W600	3 to 2 phi (2)	3.6	0.0	0	> 3.6	0.9	SA.F (2)	ST I (2)	> 3.6	6.5
W700	3 to 2 phi (2)	5.4	0.0	0	> 5.4	2.5	SA.F (2)	ST I (2)	4.5	6.0
WNW0	3 to 2 phi (2)	5.1	0.0	0	> 5.1	1.6	SA.F (2)	ST I (2)	> 5.1	7.0
WNW100	3 to 2 phi (2)	4.8	0.0	0	> 4.8	2.5	SA.F (2)	ST I (2)	> 4.8	7.0
WNW200	3 to 2 phi (2)	3.4	0.0	0	> 3.4	1.2	SA.F (2)	ST I (2)	> 3.4	5.5
WNW300	3 to 2 phi (2)	4.4	0.0	0	0.0	2.4	SA.F (2)	ST I (2)	3.8	6.5
WSW0	3 to 2 phi (2)	4.8	0.0	0	> 4.8	2.7	SA.F (2)	ST I (2)	> 4.8	7.0
WSW100	3 to 2 phi (2)	6.2	0.0	0	> 6.2	2.2	SA.F (2)	ST I (2)	5.2	7.0
WSW200	> 4 phi (2)	13.0	8.3	2	3.2	1.2	UN.SF (1), UN.SS (1)	ST I on III (1), ST II on III (1)	4.0	10.5
WSW300	3 to 2 phi (2)	3.8	0.0	0	> 3.8	1.6	SA.F (2)	ST I (2)	> 3.8	6.5
AVG		6.3	2.7	0.6	> 3.1	1.6			3.8	6.5
MAX		17.3	> 17.3	2	6.9	3.6			> 5.9	10.5
MIN		2.4	0.0	0	0.0	0.3			0.5	-1.0

Table 4.4-2.
Summary of 2002 REMOTS Results for the South Reference Area (SREF) Stations

Station	Grain Size Major Mode (# replicates)	Camera Penetration Mean (cm)	Boundary Roughness Mean (cm)	Benthic Habitat (# replicates)	Successional Stages Present (# replicates)	aRPD Mean (cm)	OSI Mean
SREF10	3 to 2 phi (2)	4.3	0.7	SA.F (2)	ST I (2)	> 4.3	7.0
SREF11	3 to 2 phi (2)	6.2	1.1	SA.F (2)	ST I (2)	3.7	6.0
SREF14	3 to 2 phi (2)	4.4	0.8	SA.F (2)	ST I (2)	> 4.4	7.0
SREF16	3 to 2 phi (2)	4.7	1.0	SA.F (2)	ST I (2)	2.9	5.5
SREF18	3 to 2 phi (2)	4.9	0.5	SA.F (2)	ST I (2)	> 4.9	7.0
SREF20	3 to 2 phi (1), 4 to 3 phi (1)	6.2	0.4	SA.F (2)	ST I (2)	4.3	6.0
SREF3	2 to 1 phi (2)	6.2	1.7	SA.M (2)	ST I (2)	> 6.2	7.0
SREF4	3 to 2 phi (2)	5.1	0.3	SA.F (2)	ST I (2)	> 5.1	6.5
SREF5	3 to 2 phi (2)	6.3	1.1	SA.F (2)	ST I (2)	> 6.3	7.0
SREF8	3 to 2 phi (2)	5.4	0.5	SA.F (2)	ST I (2)	3.2	5.5
AVG		5.4	0.8			4.5	6.5
MAX		6.3	1.7			> 6.3	7.0
MIN		4.3	0.3			2.9	5.5

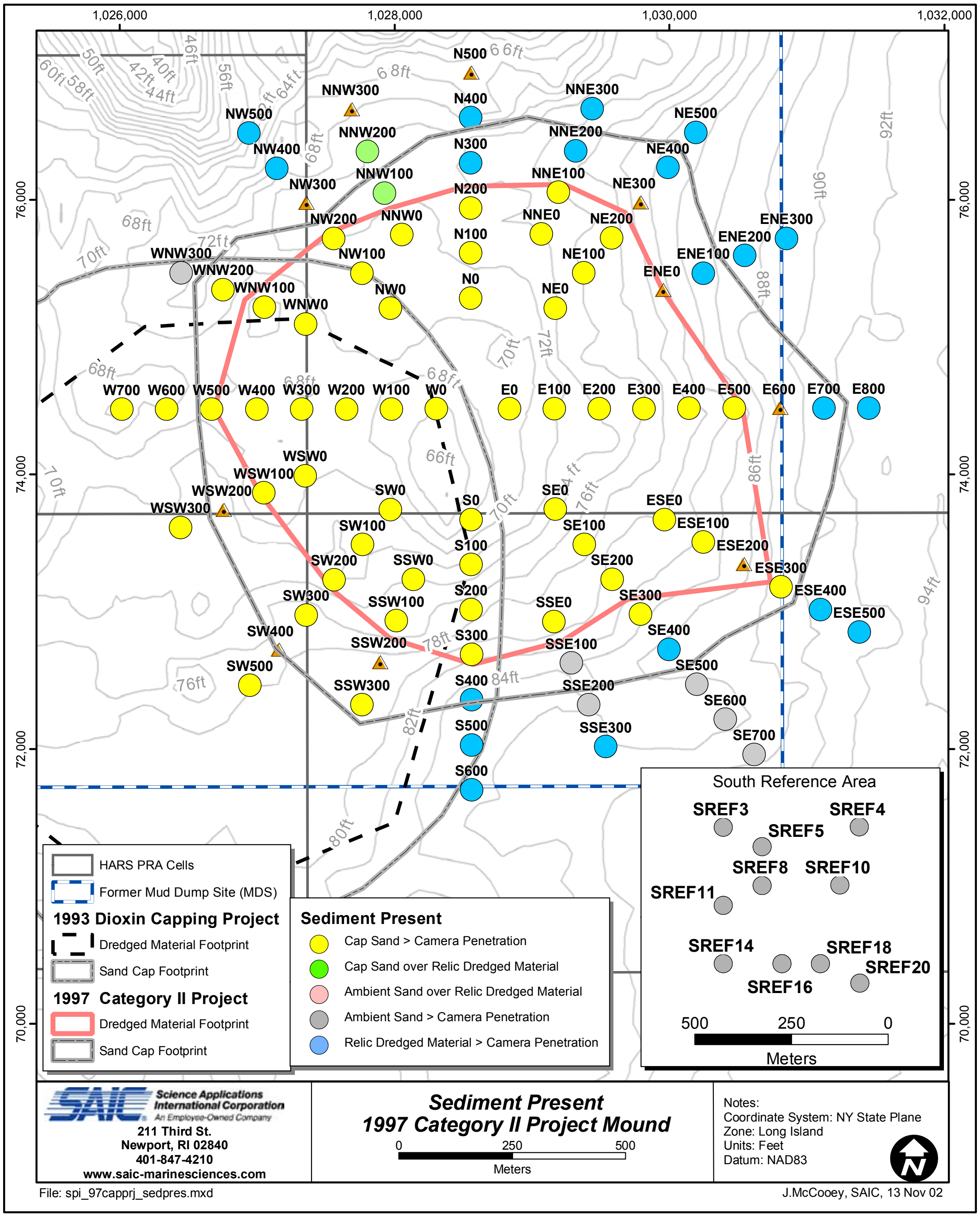


Figure 4.4-1. Map showing the distribution of cap material and dredged material at the 2002 REMOTS stations over the 1997 Category II Capping Project Area. Bathymetric contours are from the summer 2002 survey. A single symbol color indicates both replicate images from the station displayed the noted condition, while two symbol colors indicates varying conditions for each replicate image.

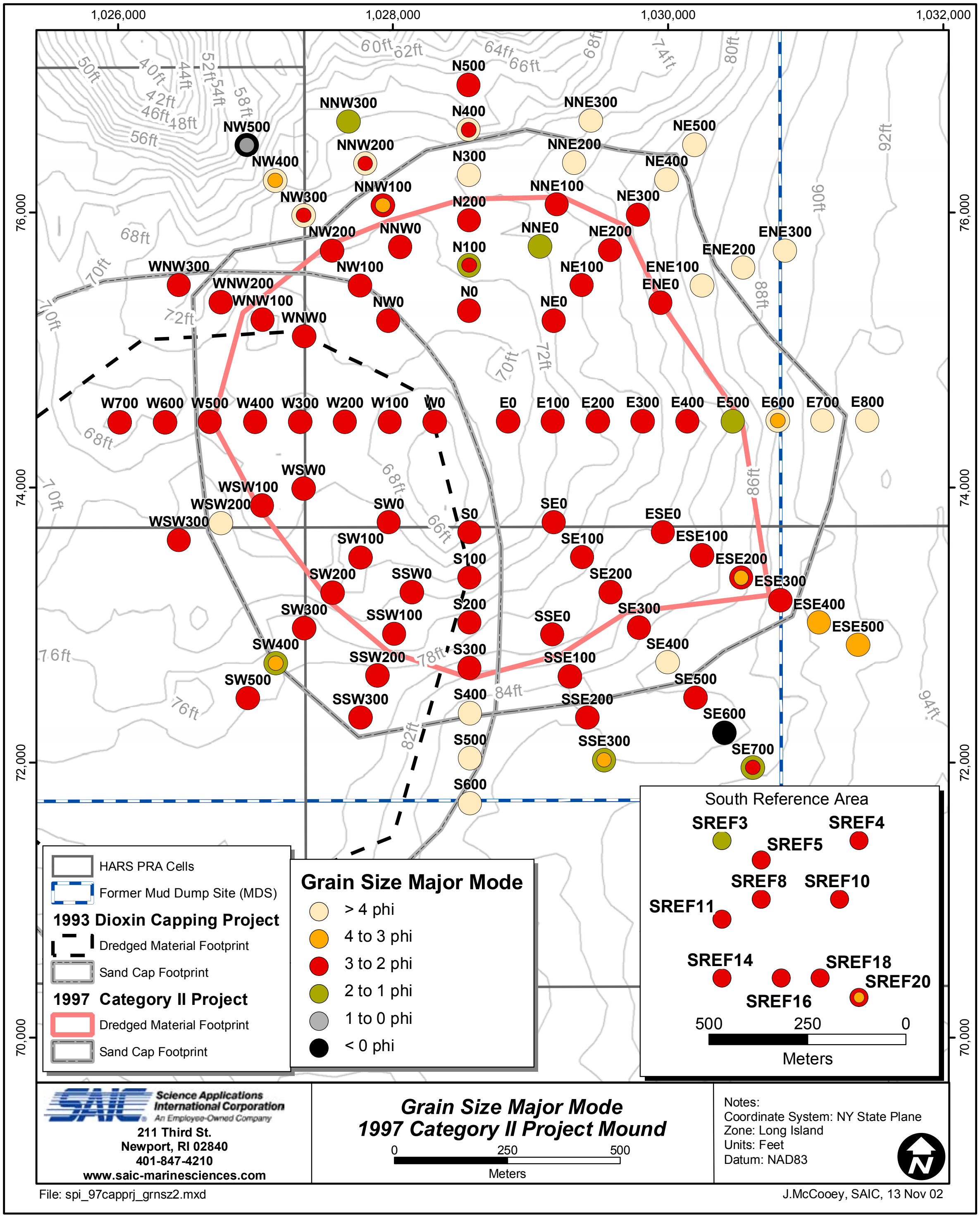


Figure 4.4-2. Map showing the grain size major mode (in phi units) at the 2002 REMOTS stations over the 1997 Category II Capping Project Area. A single symbol color indicates both replicate images from the station displayed the noted condition, while two symbol colors indicates varying conditions for each replicate image.

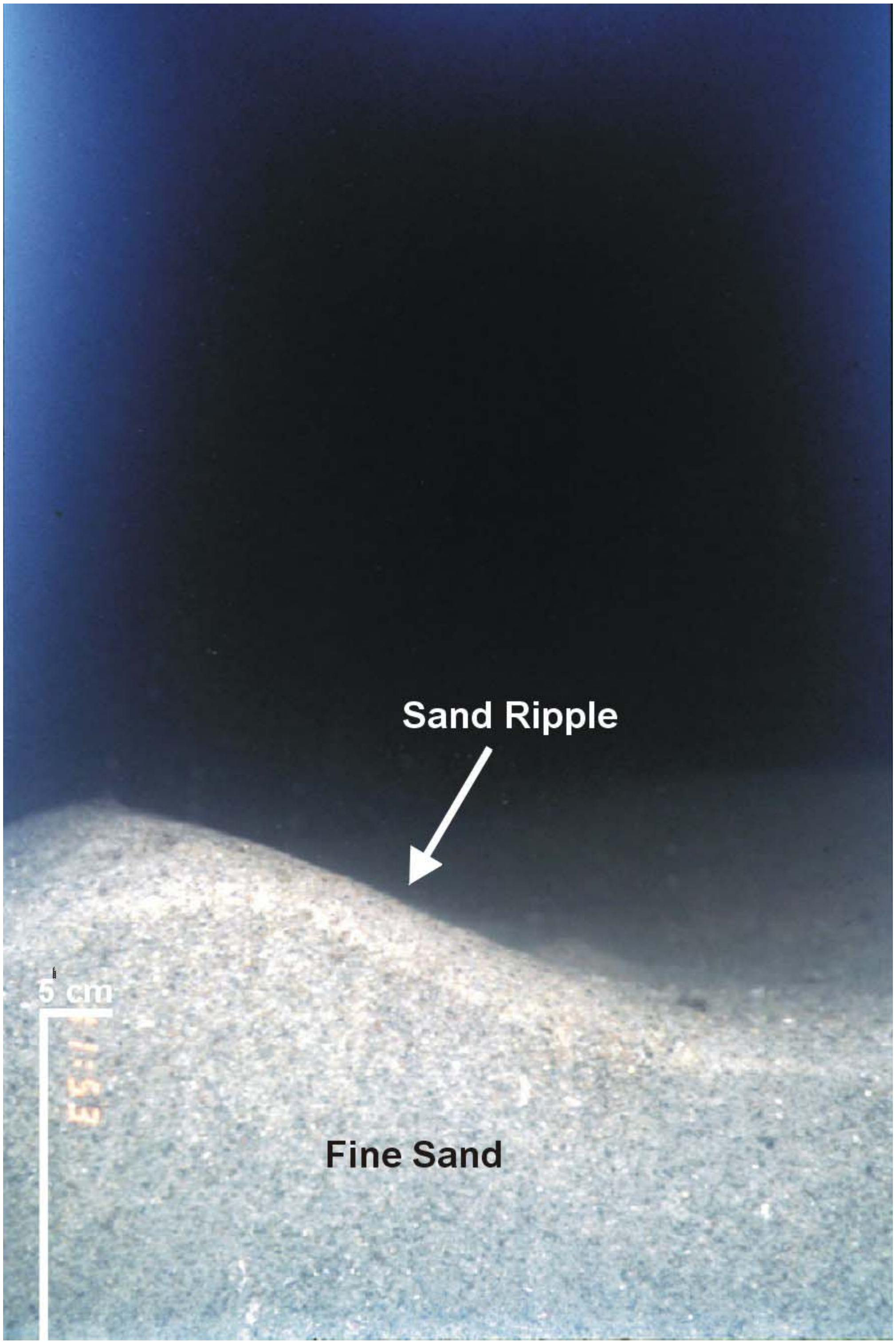


Figure 4.4-3. REMOTS image from Station S0 illustrating well-sorted, rippled fine sand (benthic habitat type SA.F and grain size major mode of 3 to 2 phi) comprising a homogenous sand cap layer over the 1997 Category II Capping Project Area.

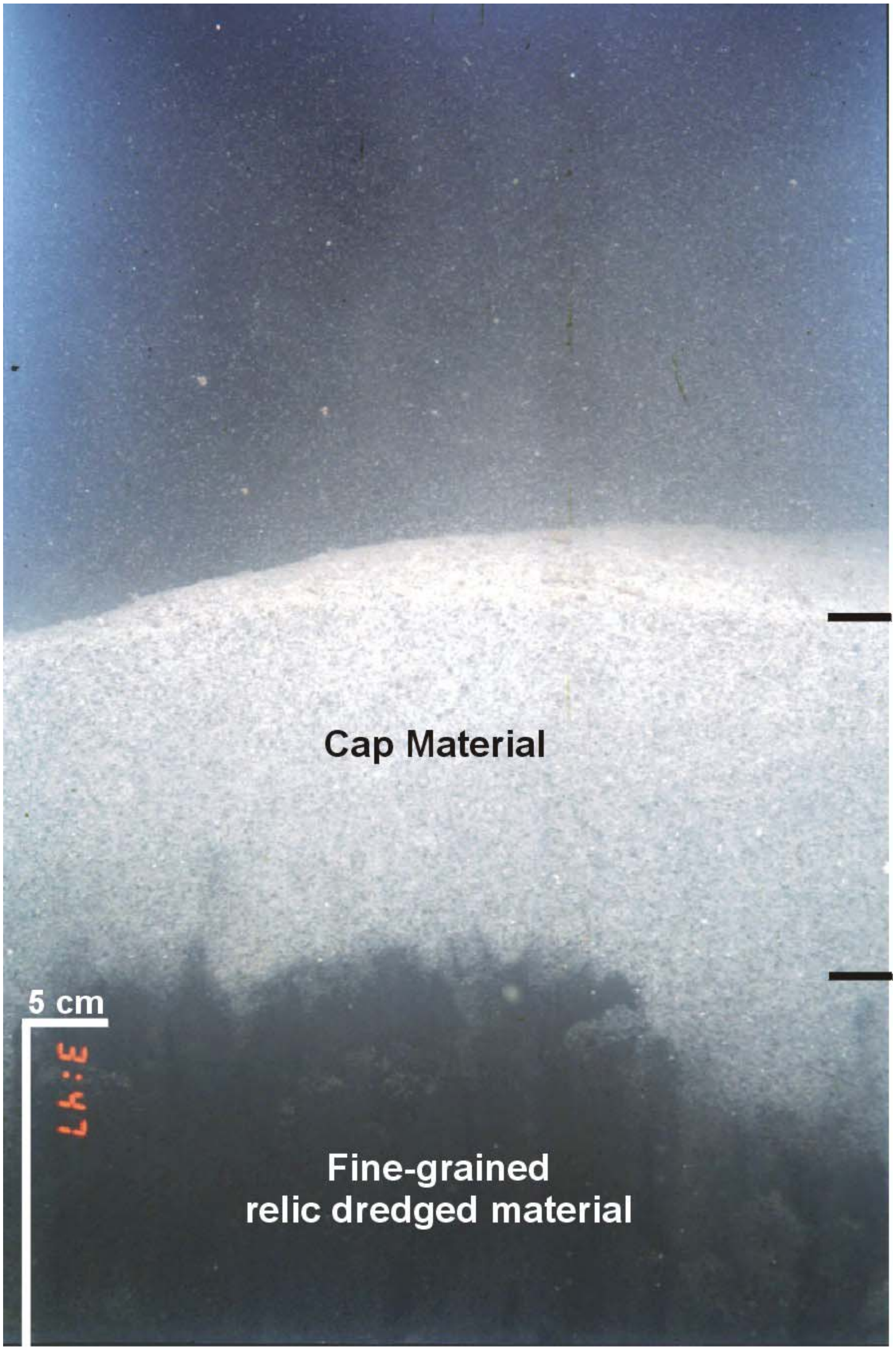


Figure 4.4-4. REMOTS image obtained from Station NNW100, located at the outer edge of the sand cap, displaying an apparent sand cap layer over fine-grained relic dredged material.

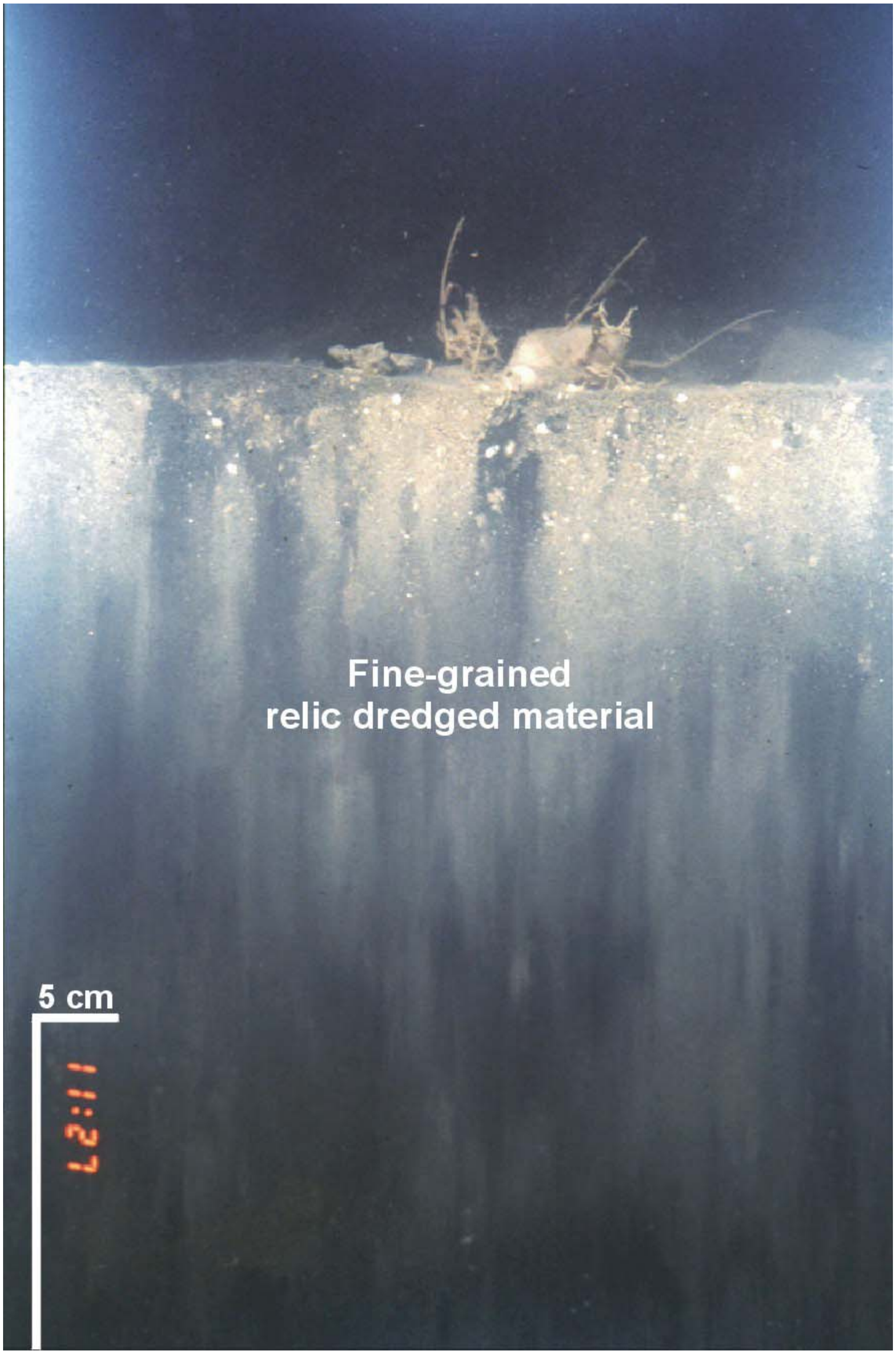


Figure 4.4-5. REMOTS image from Station S500 showing soft, muddy relic dredged material (grain size major mode of > 4 phi and benthic habitat type UN.SF) that resulted in deeper camera prism penetration at this station.

A unique layered stratigraphy was detected at Station WSW200 in the area of overlap with the 1993 Dioxin Mound. Sediment horizons consisting of sand cap material over fine-grained relic dredged material over possible previous 1993 Dioxin Mound sand cap material was observed at this station (Figure 4.4-6). Fine-grained relic dredged material had been previously detected at the 1993 Dioxin Mound Station A5 located in close proximity to Station WSW200 during the both the 1994 and 1996 postcap REMOTS surveys (SAIC 1995 and SAIC 1997a). This material was not considered to be dioxin-contaminated material, but rather it was suggested that there were small patches of mud or "mud puddles" on the cap in this area consisting of material from a subsequent disposal operation.

Stations located outside the perimeter of the capped project mound generally displayed either ambient sand or relic fine-grained dredged material (Figure 4.4-1). In particular, relic dredged material was found in areas to the north, northeast, and east of the capped project mound, as well as at three stations on the outer end of the southern transect, consistent with previous results. The dredged material typically consisted of low-reflectance (black), fine-grained sediment (silt-clay or very fine sand). It is likely that the dredged material at stations outside the cap footprint is not associated with the 1997 Category II Mound, since it lies beyond the original disposal mound footprint. This dredged material is presumed to be the result of past disposal at the MDS, which had occurred well in advance of the 1997 Category II Mound. Furthermore, this relic dredged material was observed in the areas to the northeast and south of the 1997 Category II Mound area in the baseline REMOTS survey conducted prior to the disposal operations for the 1997 Category II Mound (SAIC 1997b).

The brown fine sand on the sloping bottom southeast of the sand cap is presumed to be naturally occurring (ambient; Figure 4.4-1). Station SSE100 positioned within the capping boundary also displayed ambient sediment in both replicate images (Figure 4.4-7). Dredged material was not observed in any of the replicate REMOTS images obtained in the South Reference Area. Well-sorted fine and medium sand characterized the ambient sediments (Figure 4.4-8).

4.4.1.1 Sediment Grain Size

The grain size major mode of stations located in and around the 1997 Category II Mound area was predominately well-sorted fine sand, having a grain size major mode of 3 to 2 phi (Tables 4.4-1 and 4.4-2; Figures 4.4-2 and 4.4-3). There was little variability in grain size major mode among stations within the capped area; a few stations located near the outer edges of the capping boundary displayed either coarser medium sand (2 to 1 phi) or softer, fine-grained sandy silt or silt-clay (4 to 3 or > 4 phi). Two stations within the sand cap footprint were dominated by medium sand (2 to 1 phi); this probably reflects natural variability in the cap material from Ambrose Channel (Figure 4.4-2).

The area surrounding the cap showed greater variability in sediment grain size. In this area, surface sediments ranging in size from < 0 phi (very coarse sand and pebble/gravel) to > 4 phi (silt-clay) were noted (Figure 4.4-2). In particular, the area to the northwest of the sand cap was characterized by sediments having variable grain size; this is generally an area of hard bottom characterized by a mixture of relic dredged material, sand, pebbles, and cobbles. The finer grained sediments (grain size major modes of 4 to 3 phi and >4 phi) were indicative of historic dredged material deposits that flank the fringes of the 1997 Category II Mound (Figure 4.4-5).

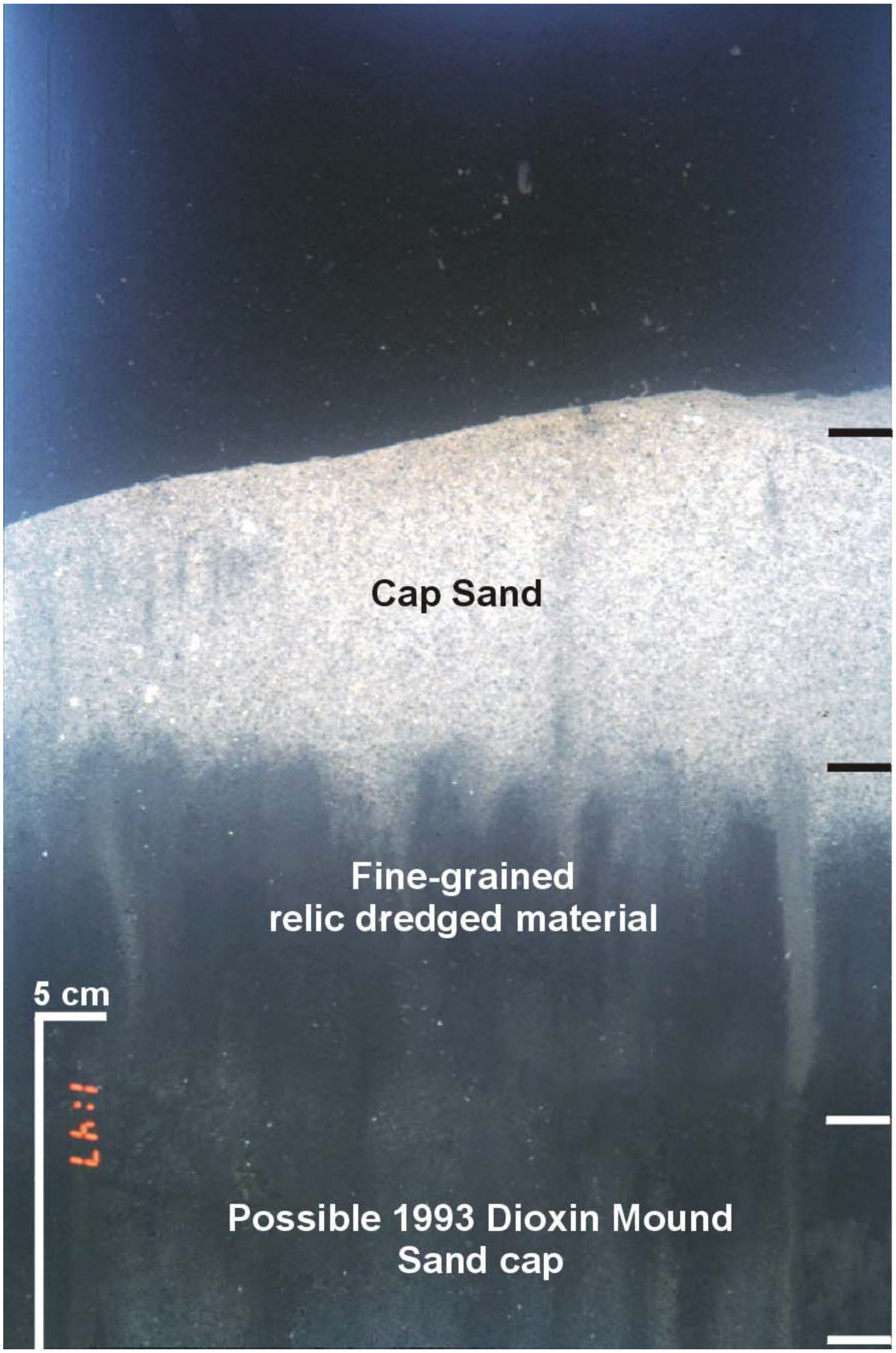


Figure 4.4-6. REMOTS image collected from Station WSW200, located in the overlapping 1993 Dioxin Mound Project Area, displaying sediment horizons consisting of sand cap material over fine-grained relic dredged material over possible previous 1993 Dioxin Mound sand cap material.

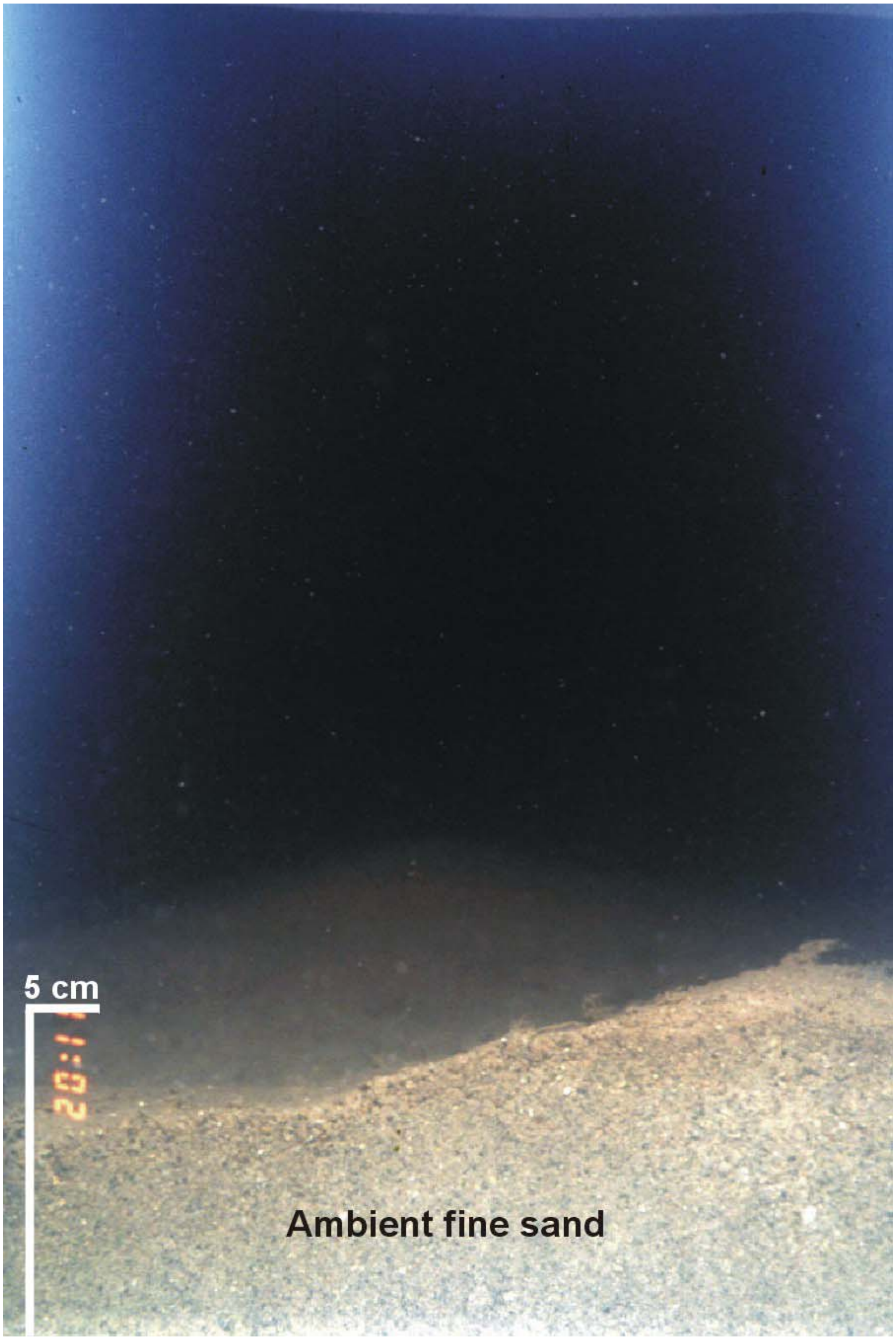


Figure 4.4-7. REMOTS image from Station SSE100, positioned within the capping boundary, illustrating ambient brown, muddy fine sand (grain size major mode of 3 to 2 phi and benthic habitat type SA.F).

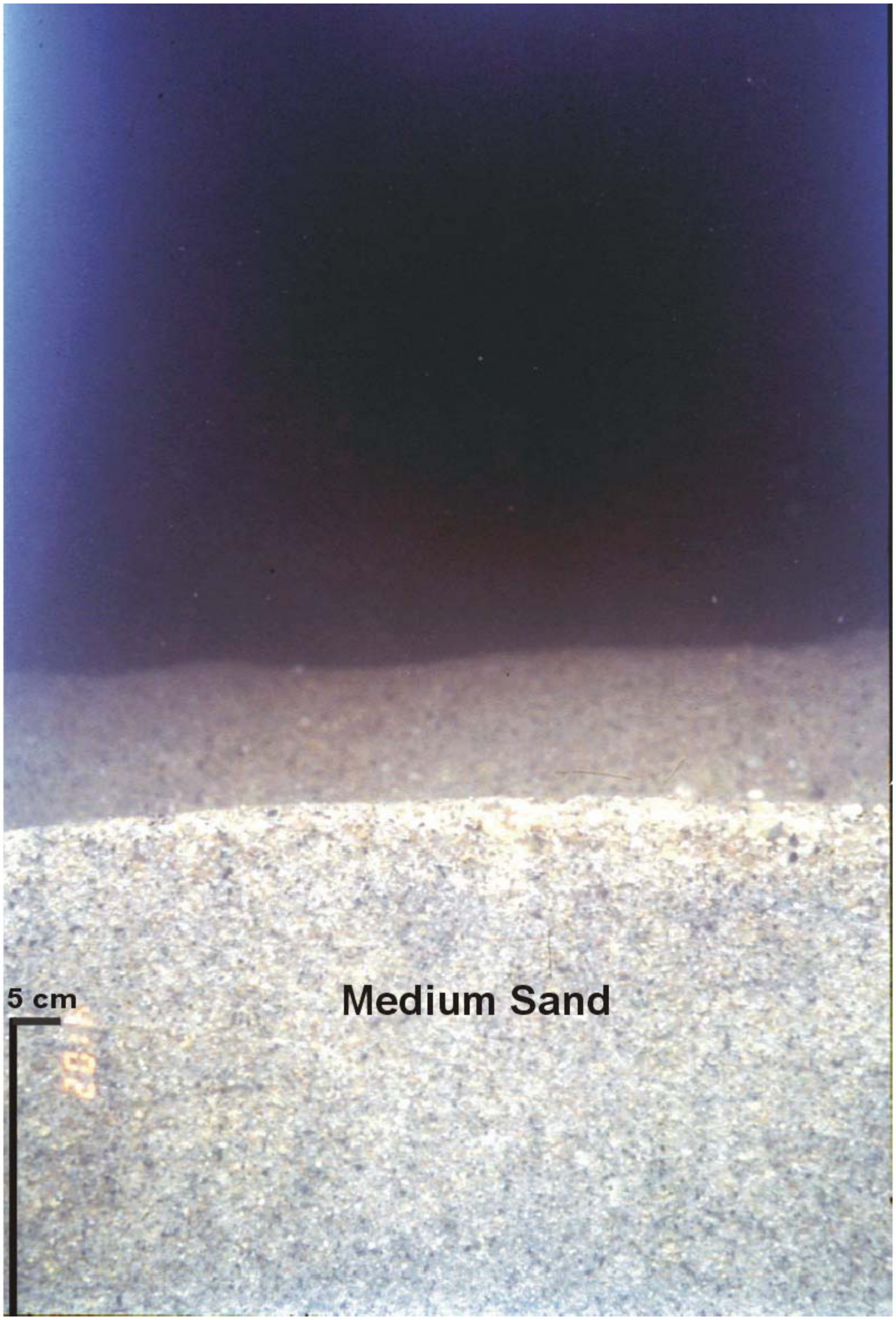


Figure 4.4-8. REMOTS image collected from South Reference Area Station SREF3 illustrating homogenous rippled medium sand (grain size major mode of 2 to 1 phi) and benthic habitat type SA.M. The aRPD depth extends beyond the camera prism penetration (> 8.1 cm).

Alternatively, larger grained sediments (1 to 0 phi and < 0 phi) were found at Stations NW500 and SE600. Dredged material comprised of rocks and pebbles mixed with brick fragments (evidence of historic disposal) characterized Station NW500, while ambient coarse sand and pebbles mixed with brick pieces characterized Station SE600 (Figure 4.4-9). Station SE600 is an area that has likely experienced past disposal as evidenced by the brick fragments, however, it has since been covered by and/or mixed with sand. The stations corresponding to the overlapping 1993 Dioxin Mound generally displayed fine sand, with a grain size major mode of 3 to 2 phi at the majority of the stations (Figure 4.4-2).

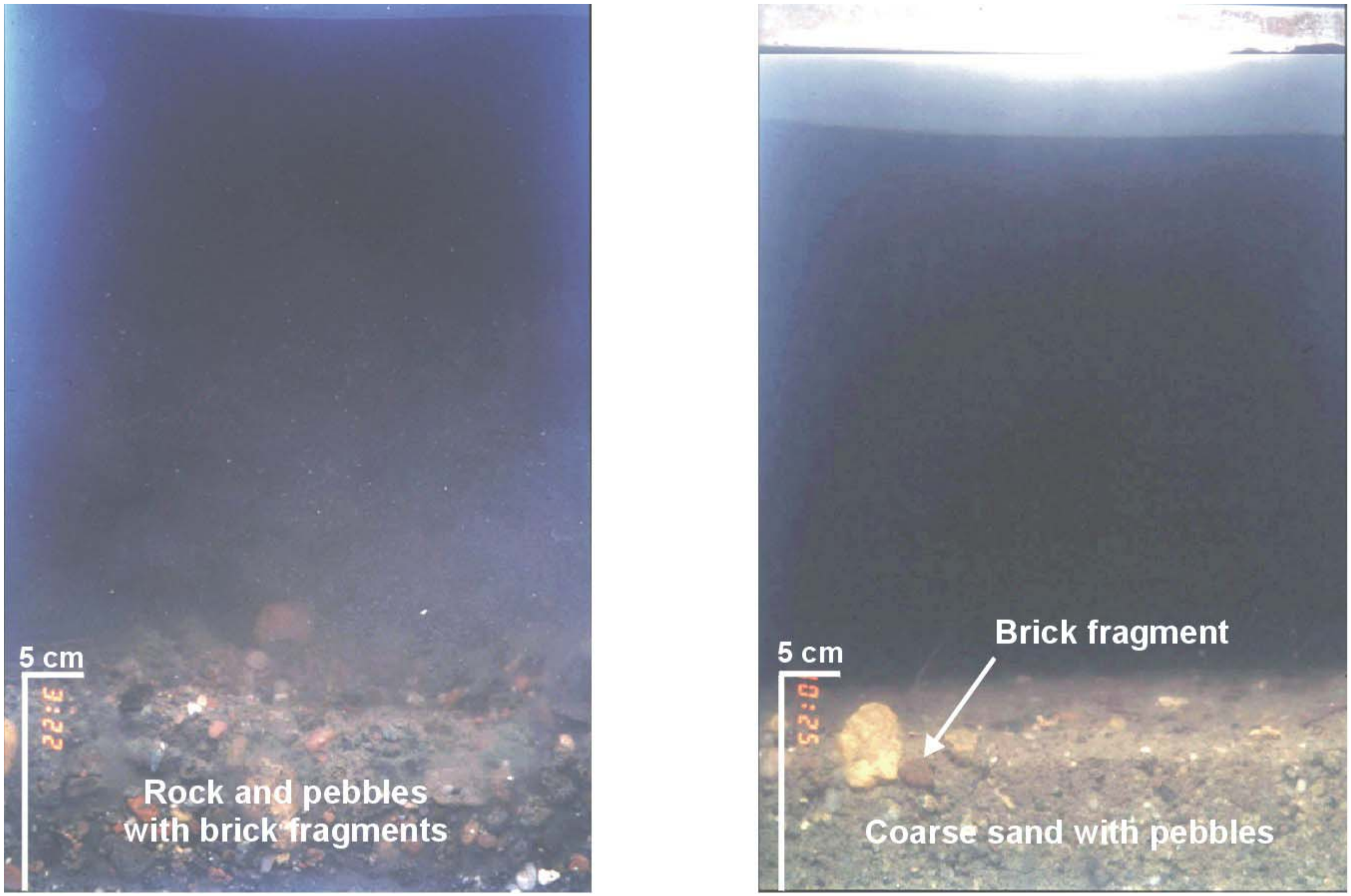
The South Reference Area was dominated by ambient fine sand, with a grain size major mode of 3 to 2 phi in all but three replicate images (Table 4.4-2 and Figure 4.4-2). The sand tended to be well-sorted and rippled. Medium sand (2 to 1 phi) was observed at Station SREF3 in the northwestern portion of the sampling area (Figures 4.4-2 and 4.4-8). Conversely, a higher fraction of finer-grained material (silty sands) occurred in one replicate of Station 20 located near the southeast corner of the South Reference Area; this finer-grained material is apparently correlated with increasing water depths and less current scouring in the southeast corner. No relic dredged material or cap sand layers were detected at the South Reference Area.

4.4.1.2 Benthic Habitat

The primary benthic habitat classification for the stations within the 1997 Category II Mound Area was fine sand (habitat type SA.F) occurring in 121 of the total 180 replicate images (67%; Table 4.4-1 and Figures 4.4-10 and 4.4-3). Muddy sediment with a high apparent proportion of very fine sand (habitat type UN.SS), unconsolidated silty sediment (habitat type UN.SI) and very soft mud (habitat type UN.SF) was detected at a number of stations located on the outer edges of the sand cap and at stations outside the capping boundary, primarily in the northeastern and southern regions of the sampling area (Figures 4.4-10 and 4.4-5). Coarser sand and gravel (benthic habitat type SA.G) or hard rock/gravel bottom conditions (benthic habitat type HR) were mainly detected in the outer stations of the northwest and southeast transects (Figures 4.4-9 and 4.4-10). Station NW400 showed extreme variability with benthic habitat types HR and UN.SI present in the same station. Benthic habitat types at the South Reference Area were similar to those within the sand cap boundary, with fine sand (benthic habitat type SA.F) occurring in all but one station (Table 4.4-2 and Figure 4.4-10). Consistent with grain size results at this station (SREF3), the benthic habitat classification was SA.M (medium sand; Figure 4.4-8).

4.4.1.3 Camera Penetration

The depth of penetration of the REMOTS camera prism can be used to map gradients in the bearing strength (hardness) of the sediment. This hardness parameter is useful for distinguishing between a relatively thick (>20 cm) layer of sand cap material or soft bottom related to the presence of thin caps or underlying silt/clay. Freshly deposited sediments or older, highly bioturbated sediments tend to be soft, while compacted sands are hard and resist camera prism penetration.



A **B**

Figure 4.4-9. REMOTS images from Stations NW500 (A) and SE600 (B) displaying hard bottom conditions. Relic dredged material composed of rocks and pebbles mixed with coarse sand and brick fragments (0 to –1 phi and benthic habitat type HR) characterized the sediment in image A, while ambient brown coarse sand with pebbles and brick fragments were noted in image B (0 to –1 phi and benthic habitat type SA.G).

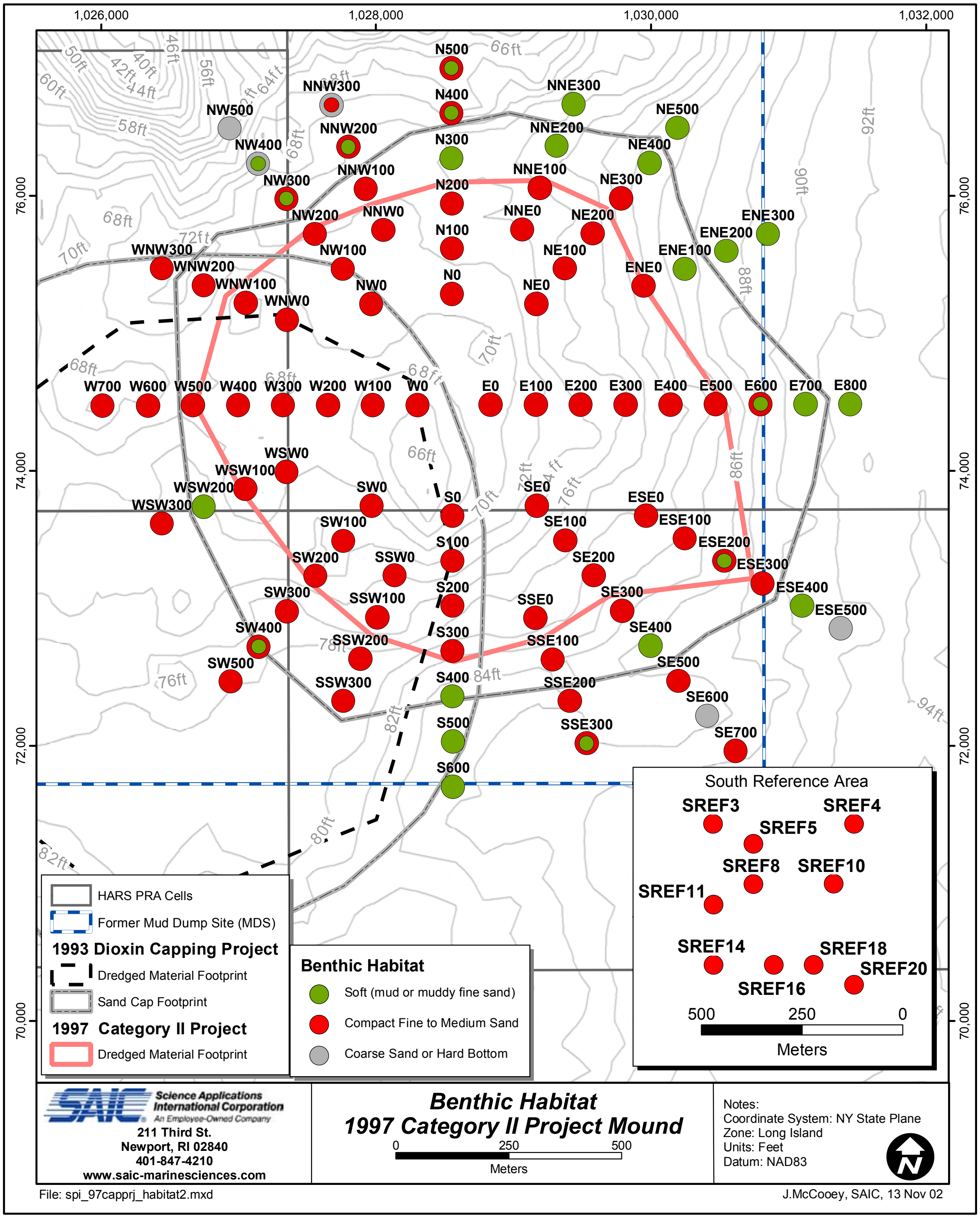


Figure 4.4-10. Benthic habitat classifications at the 2002 REMOTS stations over the 1997 Category II Capping Project Area. A single symbol color indicates both replicate images from the station displayed the noted condition, while two symbol colors indicates varying conditions for each replicate image.

Mean camera prism penetration measurements ranged from 2.4 cm at Station SE500 to 17.3 cm at Station ENE300, with an overall average of 6.3 cm (Table 4.4-1 and Figure 4.4-11). These low camera prism measurements reflect the presence of compact sand cap material or hard bottom conditions at various stations that tended to resist deep penetration of the sediment-profile camera. Alternatively, deeper camera penetration measurements generally corresponded to stations displaying older, softer and/or bioturbated fine-grained dredged material (> 4 phi) that was uncapped or only thinly capped lying beyond the project boundary on the NE, ENE, and S transects (Figures 4.4-11 and 4.4-5). Overall, the relatively narrow range of values for stations within the sand cap suggested spatial uniformity in geotechnical properties of the cap within the capping boundary. Apparent hard bottom conditions (cobble and rock or compact sand) at several outer stations along various transects (Stations ESE500, NE300, NW500, SE500, and SSE300) resulted in substantially lower camera penetration depths and prevented the analysis of key parameters (e.g., aRPD, successional status, and OSI) in certain replicate images from these stations.

Mean camera prism penetration measurements at the South Reference Area ranged from 4.3 cm at Station SREF10 to 6.3 cm at Station SREF5 (Table 4.4-2 and Figure 4.4-11). The overall average of 5.4 cm was similar to the values observed within 1997 Category II Mound (6.3 cm) and is indicative of relatively firm sediment (sand). Most of the higher penetration values were found in the northwest corner of the South Reference Area; the camera penetration was surprisingly high at SREF3 where benthic habitat SA.M was observed. No other consistent patterns or gradients in penetration depth were apparent within the sandy sediments of the South Reference Area.

4.4.1.4 Boundary Roughness

Small-scale boundary roughness values ranged from 0.3 cm at Station ENE200 to 3.6 cm at Station NE200, with an overall average of 1.6 cm (Table 4.4-1 and Figure 4.4-12). Values in this range reflect a moderate amount of small-scale surface relief due primarily to physical processes. Surface roughness at stations within the 1997 Category II Mound was attributed to physical factors in 89% of the replicate images (170 of the total 190 images) as a result of bedforms (sand ripples) at the sediment-water interface (Figures 4.4-12 and 4.4-13). The well-sorted fine sand observed at the sediment surface throughout the capped area exhibited ripples which were typically a few centimeters in height. The ubiquitous presence of ripples suggests that these sands are subject to bed-load transport, occurring primarily as a result of wave-induced bottom scour during high-energy storm events.

Stations within the capping boundary characterized by coarser grained sediments (fine sand) had a higher frequency of sand ripples and subsequent higher boundary roughness values compared to the surrounding stations generally characterized by fine-grained relic dredged material having little small-scale relief. A small percentage of the remaining replicate images displayed biogenic surface roughness due to the presence of dense polychaetes, amphipod stalks (i.e., “stick amphipods” of the Family Podoceridae), biological surface reworking by burrowing infauna (burrow openings), shallow-dwelling bivalves (*Nucula* sp.), and fecal layers/mounds at the sediment-water interface of primarily fine-grained relic dredged material (Figure 4.4-14).

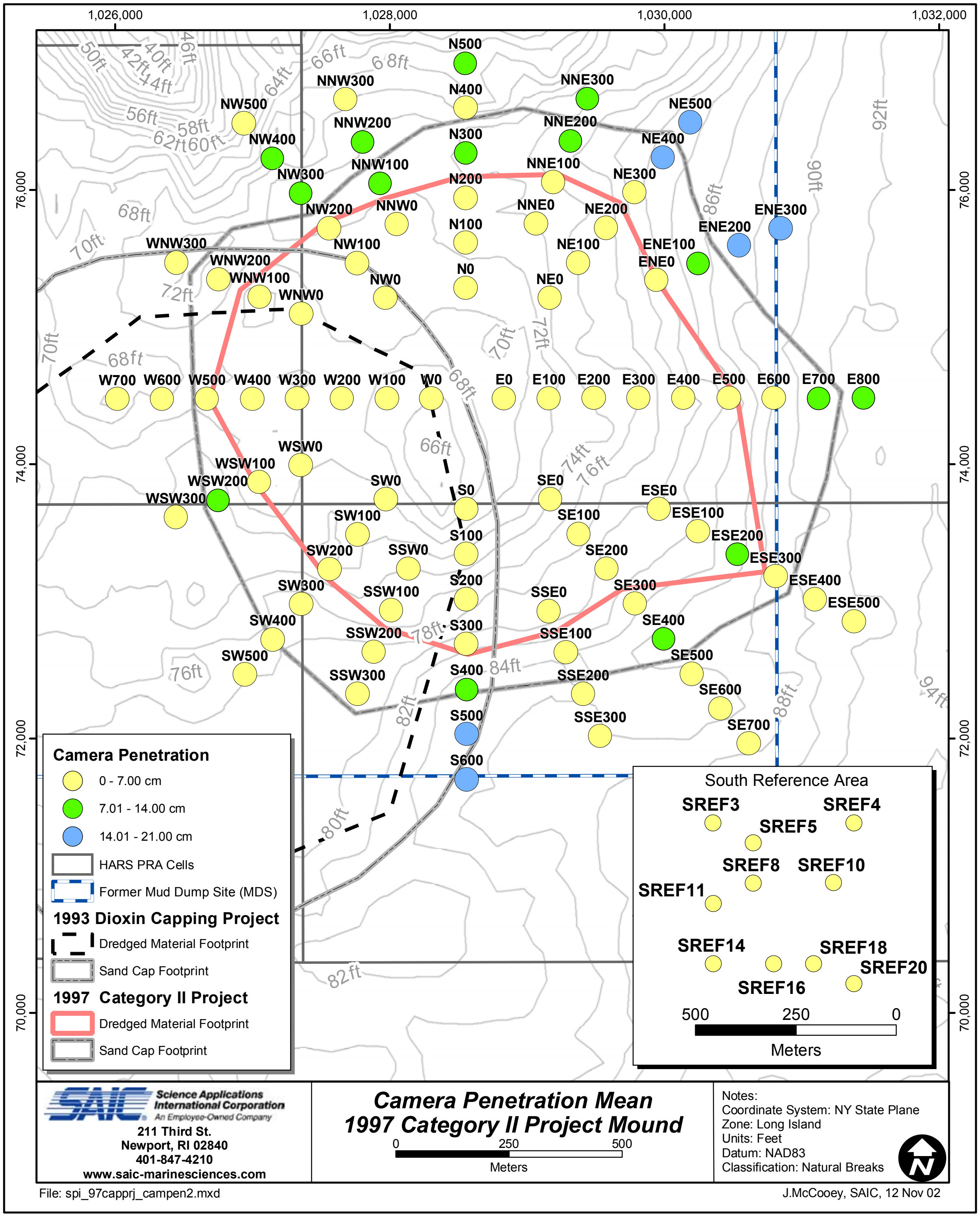


Figure 4.4-11. Map of average camera prism penetration depth values (cm) at the 2002 REMOTS stations over the 1997 Category II Capping Project Area.

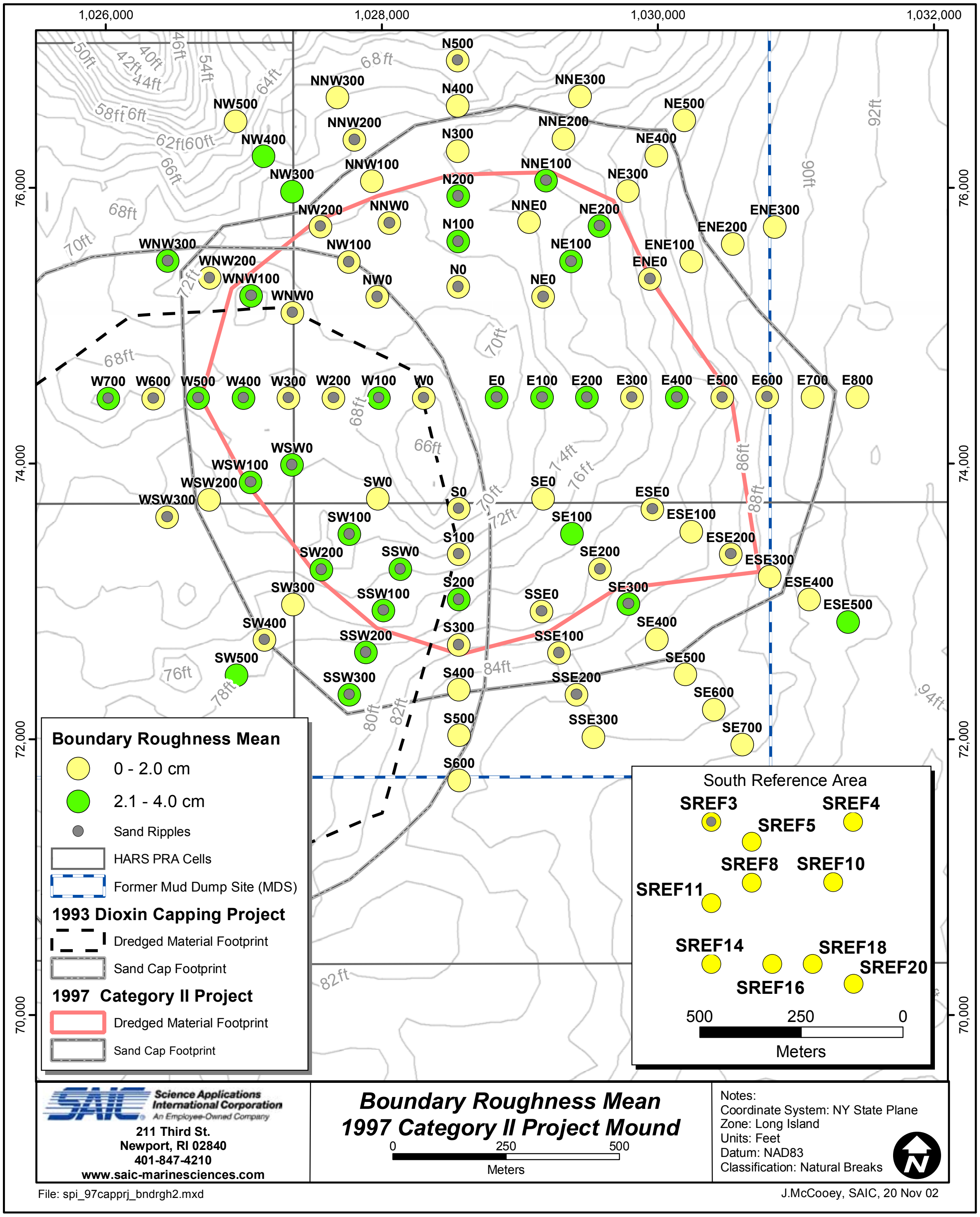


Figure 4.4-12. Map of average boundary roughness (cm) at the 2002 REMOTS stations over the 1997 Category II Capping Project Area.

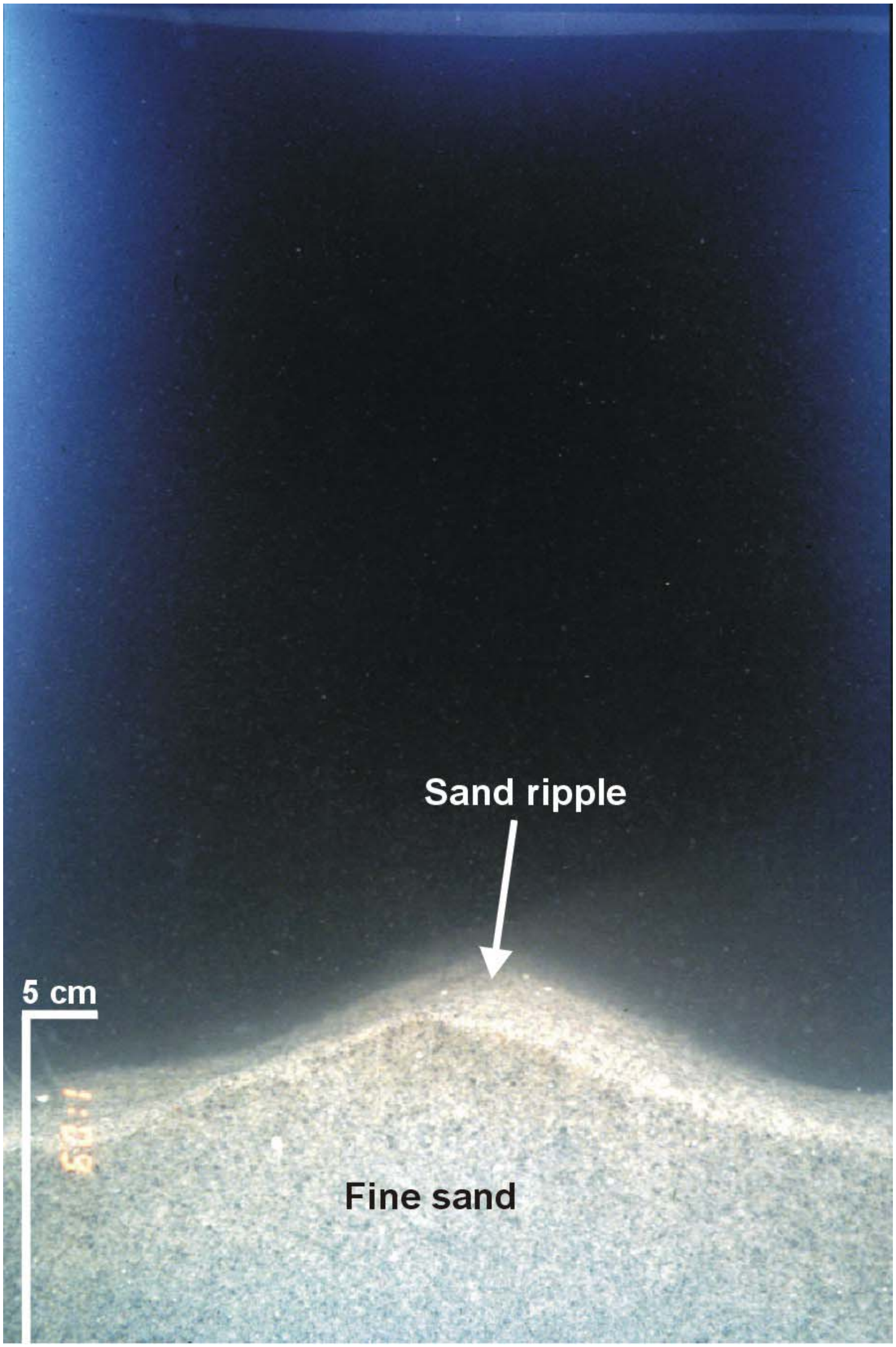


Figure 4.4-13. REMOTS image from Station SW100 illustrating physical surface roughness as a result of bedforms. A transected sand ripple is visible at the sediment-water interface.

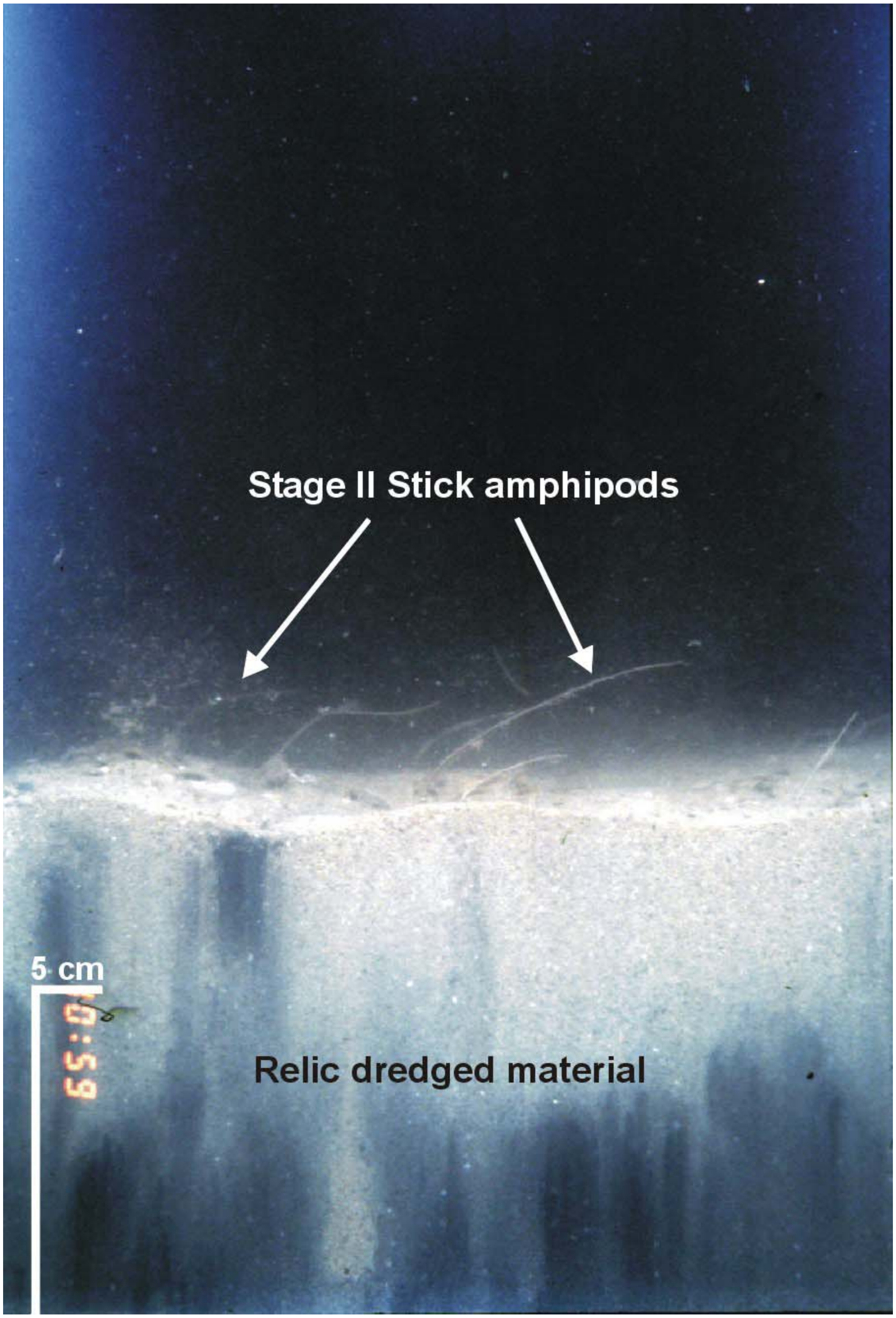


Figure 4.4-14. REMOTS image from Station NNE200 illustrating biogenic surface roughness as a result of Stage II stick amphipods and a fecal mound at the sediment-water interface of the relic dredged material. Amphipods are visible on the stalks.

Small-scale boundary roughness values for the replicate images obtained in the South Reference Area were lower than those calculated for stations within the 1997 Category II Mound Area (overall average of 1.6 cm). Mean boundary roughness values ranged from 0.3 cm at Station SREF4 to 1.7 cm at Station SREF3 (Table 4.4-2 and Figure 4.4-12). The overall average value of 0.8 cm indicates little small-scale surface relief. Surface roughness was attributed primarily to physical processes, with the exception of two replicates, which displayed biogenic surface roughness as a result of sand dollars at the sediment-water interface. The high boundary roughness observed at Station SREF3 was the result of sand rippling (sand wave) at the sediment surface; this was the only reference station displaying sand ripples (Figure 4.4-8).

The sediment plan view images supported the results of the REMOTS analysis, showing primarily high reflective surface sediments (sand cap) and the lower reflective sediments that typically comprise more fine-grained sediments (i.e., >4 phi) including silts and clay (Figure 4.4-15). Two stations (Stations ESE400 and NE400) did not have an analyzable plan view image due to poor image quality. Sediment plan view images revealed that stations within the capping boundary were dominated by rippled, well-sorted fine and medium grained sands (Figure 4.4-15). Plan view images from stations outside the capping boundary also showed relatively good agreement with the REMOTS images and confirmed the presence of hard bottom conditions at various stations (Figures 4.4-16 and 4.4-17). Consistent with the REMOTS results, reference station SREF3 was the only reference station displaying sand rippling at the surface in the sediment plan view image. Furthermore, a significant amount of shell material was detected in the plan view images throughout the surveyed area.

While the cap sand generally occurred in discrete layers or thicknesses greater than camera penetration at stations within the capping boundary, small patches or puddles of mud (dredged material) were visible at the sediment surface in both the REMOTS and plan view image of Station W700 located within the overlapping region of the 1993 Dioxin Mound Area (Figure 4.4-18). A patch of reduced sediment presumed to be relic dredged material was visible just below the sediment surface in the REMOTS image, while patches of dredged material were visible at the crest of the sand ripples in the plan view image (Figure 4.4-18). It appears that wave-induced bottom scour has exposed the underlying small patches of historic dredged material that had been previously covered by cap material.

Although the capping sands were “clean,” a thin layer of flocculent mud/organic matter was observed at the sediment surface of various plan view images (Figure 4.4-15B). This material has been present in past surveys and has been interpreted as the product of detrital production (seston) from the overlying water column and/or fine-grained material resuspended from the ambient bottom (SAIC 1999). None of this flocculent material appears to be in the process of incorporation into the ripped sand; no flocculent material was detected in the subsurface sediments of any of the REMOTS images. It is likely, however, that this transient flocculent material is being utilized as detrital food by Stage I species that have settled on the cap (SAIC 1999).

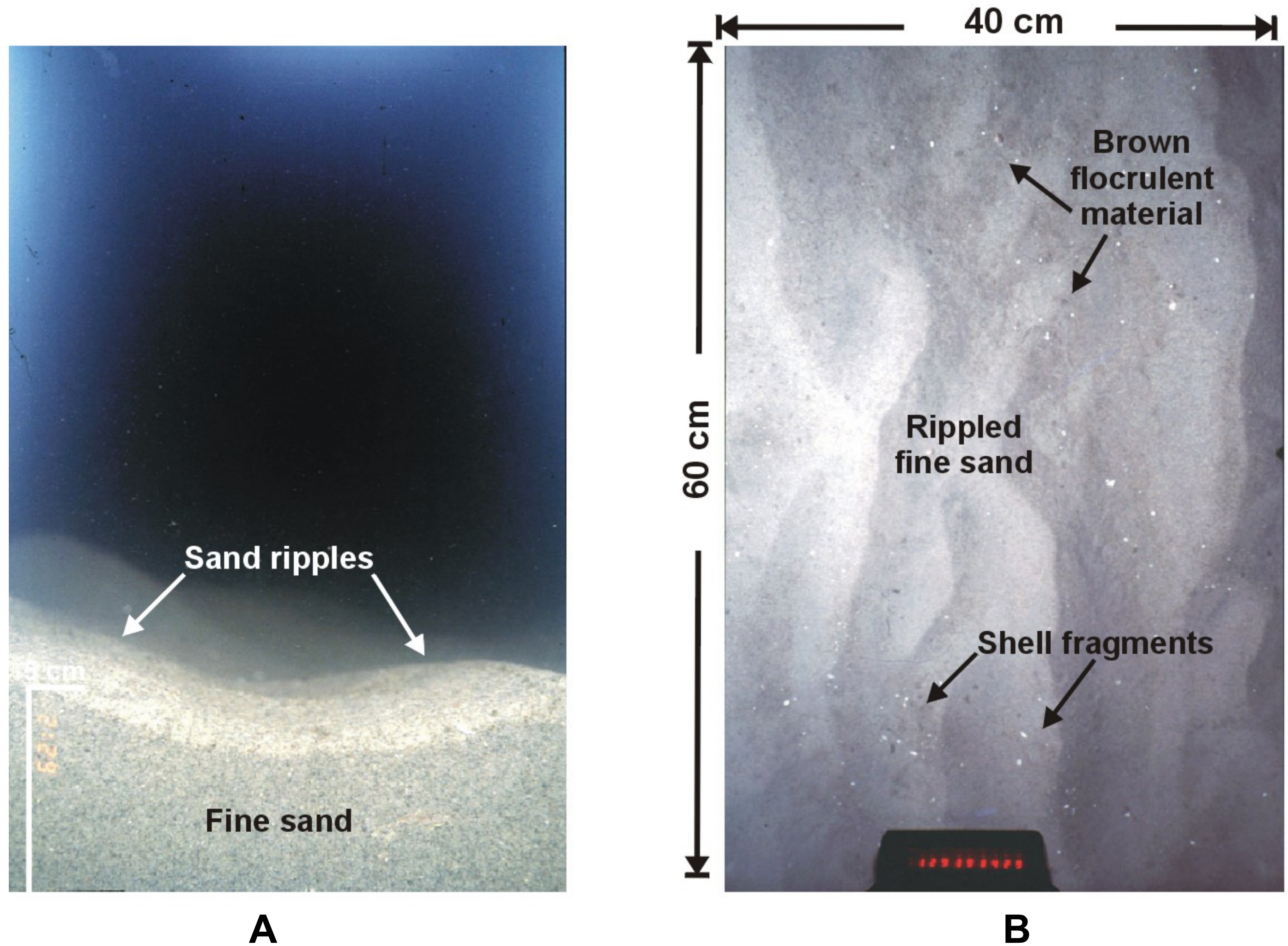


Figure 4.4-15. REMOTS image (A) and corresponding plan view image (B) obtained from Station W100 showing the rippled, fine sand characterizing the cap material. A thin layer of brown flocculent matter is visible at the sediment surface of the plan view image.

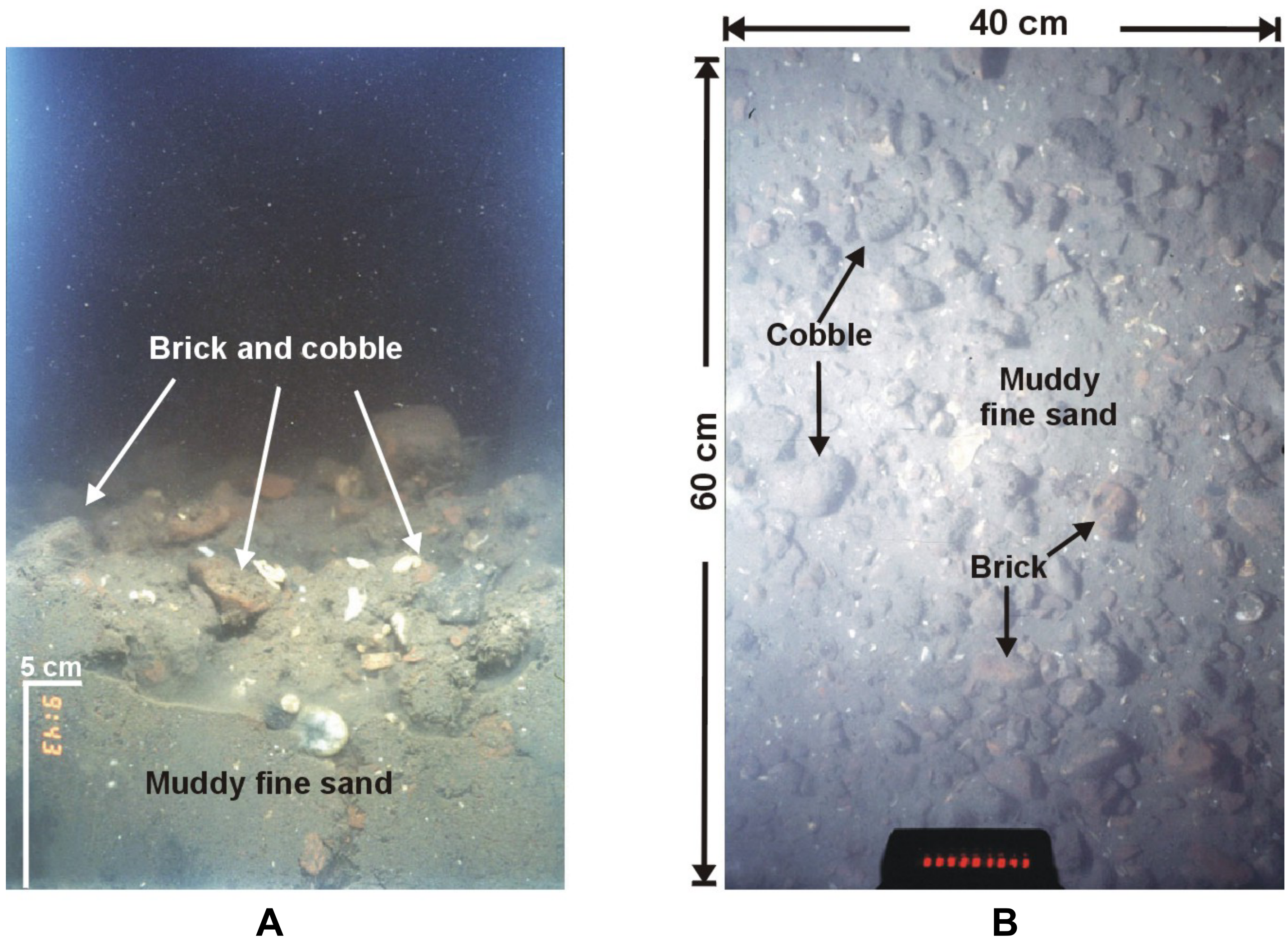


Figure 4.4-16. REMOTS image (A) and corresponding plan view image (B) from Station ESE500, located outside the capping boundary, illustrating relic dredged material comprised of brick and cobble over muddy fine sand.

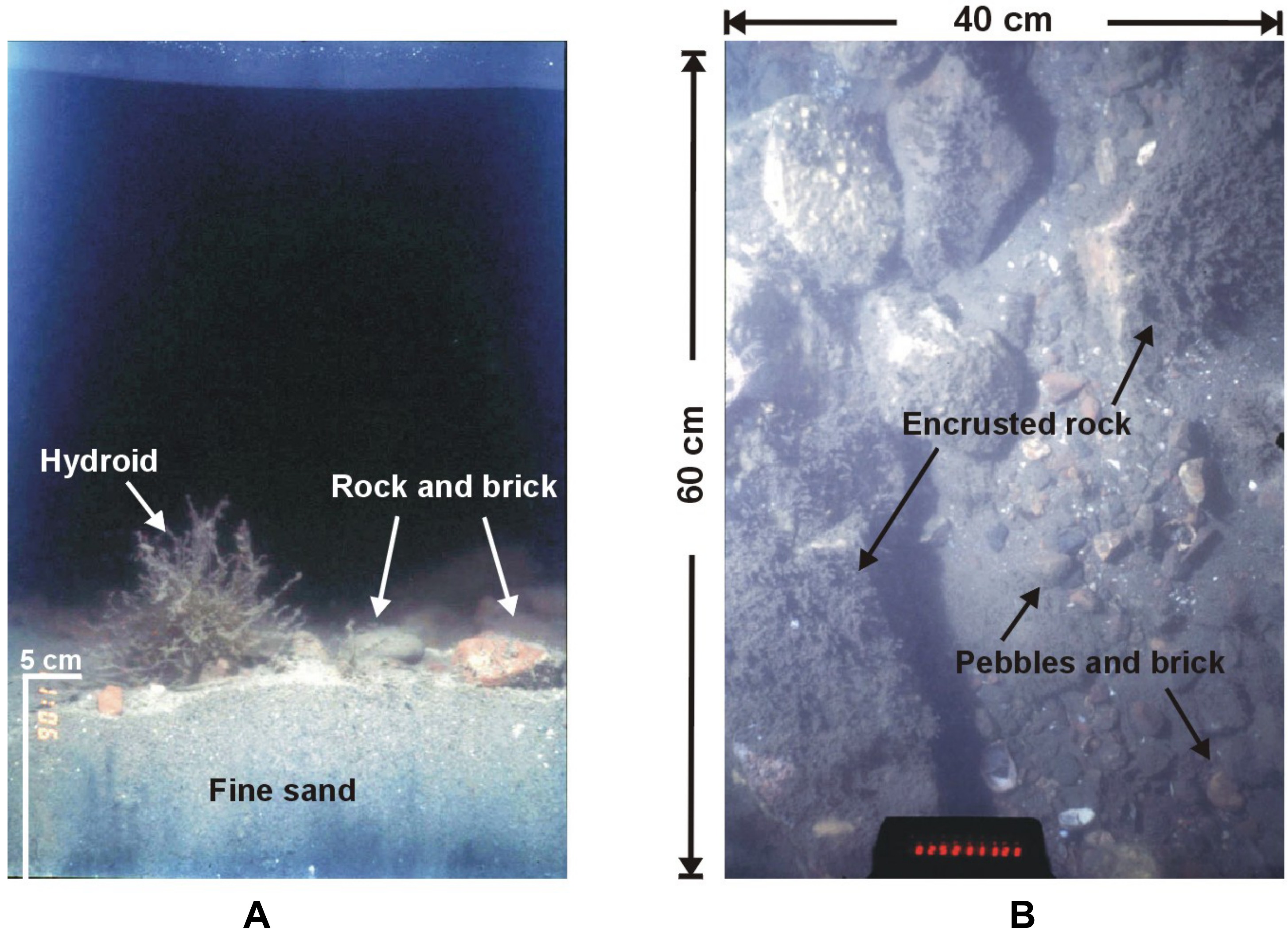
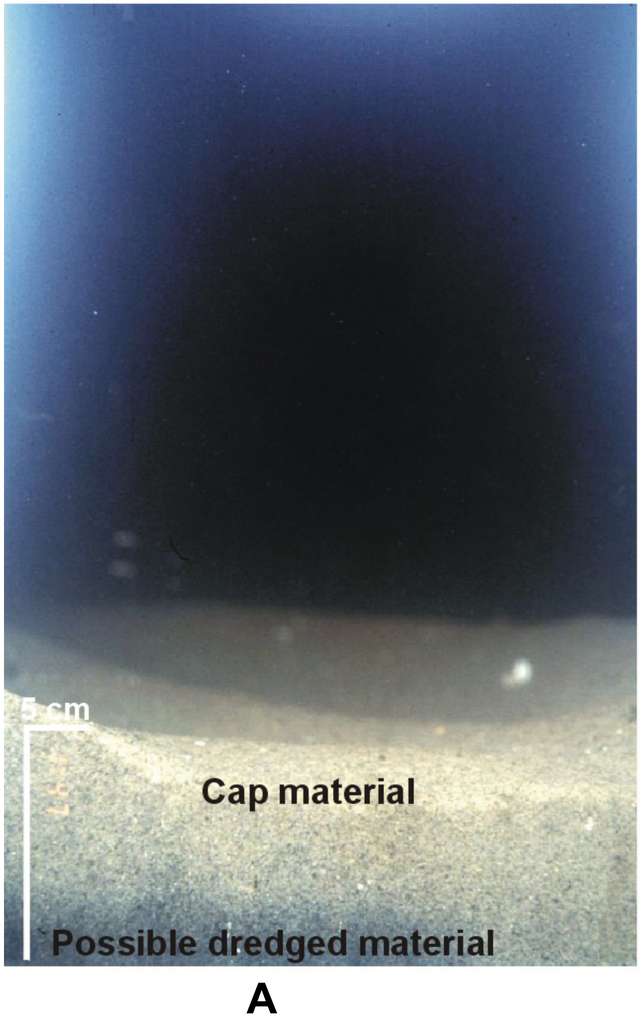


Figure 4.4-17. REMOTS image (A) and corresponding plan view image (B) from Station N400 displaying similar bottom conditions, with relic dredged material consisting of encrusted rock and brick fragments over fine sand.



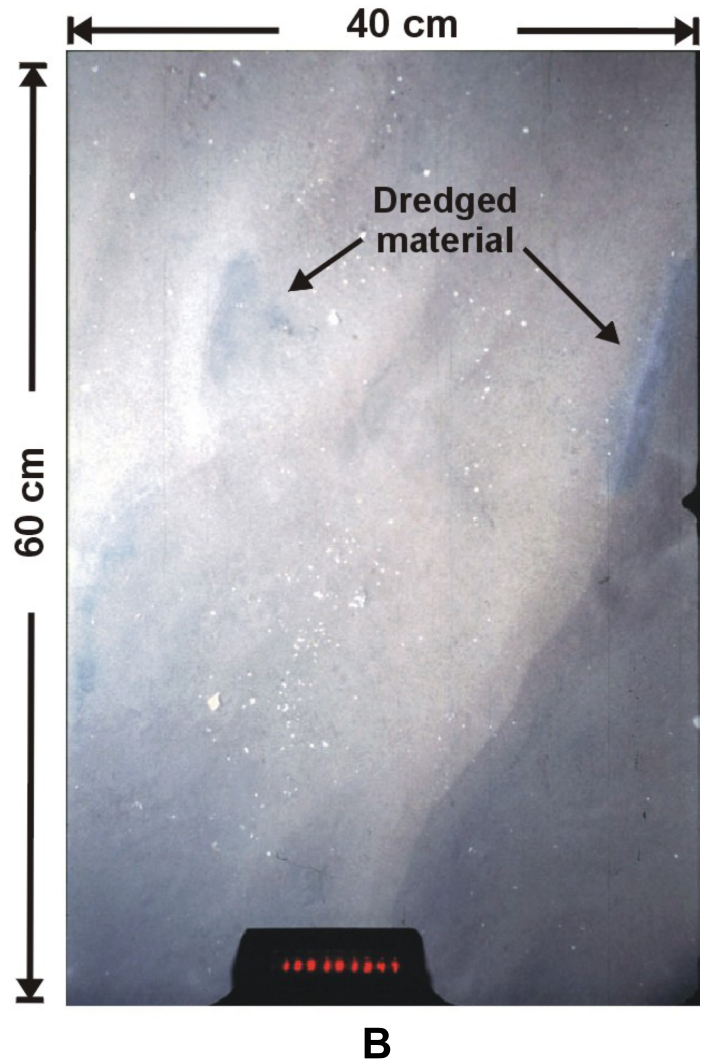


Figure 4.4-18. REMOTS image (A) and corresponding plan view image (B) from Station W700 showing small patches or “puddles” of dredged material at the sediment surface of the cap material.

Small-scale variability was detected within various stations with respect to grain size and benthic habitat. In particular, the REMOTS image from Station E800 showed muddy fine sand (relic dredged material), while the sediment plan view image revealed a hard bottom consisting of cobbles, pebbles and sand mixed with brick fragments (Figure 4.4-19). This discrepancy indicates small-scale spatial variability in sediment in the outer portions of the survey area just beyond the sand cap footprint due to historic dredged material placement in that area.

A number of biological features were detected within the sediment plan view images including starfish, infaunal burrows, polychaete and amphipod tubes, hydroids, fecal casts/mounds, crabs, and sand dollars (*Echinarachnius parma*) (Figure 4.4-20). Sand dollars, often in dense aggregations, were more commonly found within the sandy sediments of the South Reference Area (Figure 4.4-21). These organisms often appeared in the corresponding REMOTS images (Figure 4.4-21).

4.4.2 Biological Conditions and Benthic Recolonization

Three REMOTS parameters were used to assess overall benthic habitat quality within the survey area: aRPD depth, infaunal successional status, and OSI.

4.4.2.1 Infaunal Successional Stages

The successional status for stations within the 1997 Category II Project Mound Area consisted predominately of small, surface-dwelling organisms (Stage I; Table 4.4-1 and Figure 4.4-22). Stage I pioneering, tubicolous polychaetes occurred alone at 73% of the stations (66 of the total 90 stations), and represented the highest successional stage present at these stations (Figures 4.4-22 and 4.4-23). However, Stage II infaunal amphipods and shallow dwelling infaunal bivalves (*Nucula* sp.) as well as advanced head-down, deposit-feeding infauna were detected at several of the outer radial transect stations that were characterized by finer-grained sediment (Figure 4.4-22). A Stage II community consisting of infaunal amphipods (*Ampelisca* sp. and/or Family Podoceridae) and shallow-dwelling infaunal bivalves (*Nucula* sp.), as the apex successional stage (Highest Successional Stage Present in Figure 4.4-22), was detected at 15 of the 90 stations (17%; Figures 4.4-22, 4.4-14, and 4.4-24). Dense *Nucula* were visible at the sediment-water interface of Station S600 (Figure 4.4-24); high densities of *Nucula* have been detected in the soft, relic dredged material at these southern transect stations in previous surveys (SAIC 1999). Amphipod stalks, often accompanied by amphipods, were visible at the surface of many of these stations (Figure 4.4-14).

Evidence of Stage III head-down, deposit-feeding infauna (active feeding voids in the subsurface sediments) was detected in 4% of the replicate images. Stage III taxa, as the highest successional stage present, occurred exclusively at the outer radial transect stations characterized by organic-rich, fine-grained dredged material. When present, Stage III organisms were accompanied by either Stage I polychaetes or Stage II amphipod tubes or *Nucula* sp. at the sediment-water interface (Stage I on III and Stage II on III successional status, respectively; Figure 4.4-25). Station NW500 was given an indeterminate successional status designation due to hard bottom conditions.

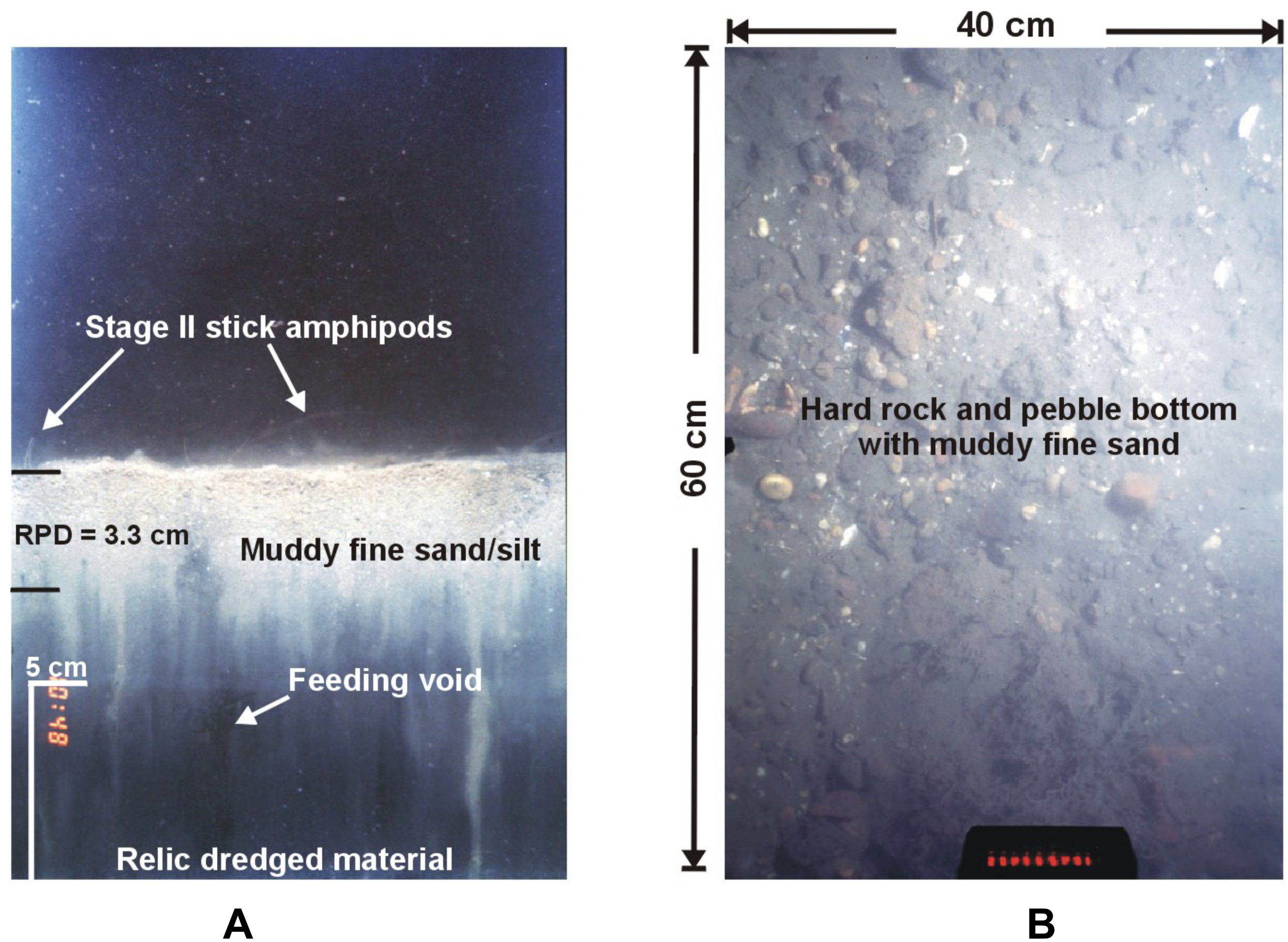


Figure 4.4-19. REMOTS image (A) and corresponding plan view image (B) from Station E800 illustrating variability in sediment composition at this station. Fine-grained material (A) and a hard, rock and pebble bottom (B) were observed within the same station. A deep aRPD depth (3.3 cm) coupled with stick amphipods at the sediment-water interface over a Stage III feeding void in the subsurface sediments (Stage II on III successional status) resulted in an OSI value of +10 indicative of undisturbed benthic habitat quality in image A.

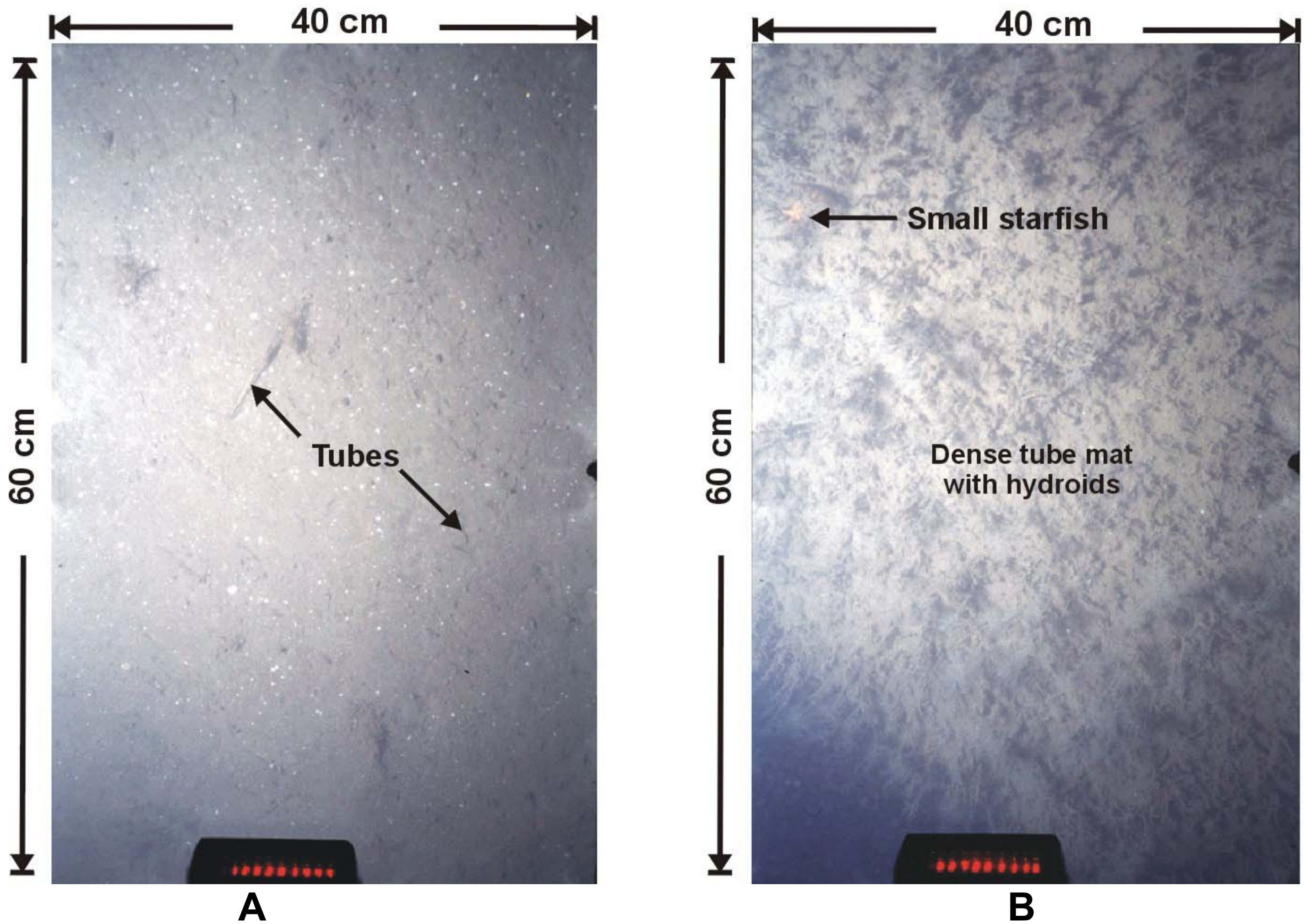


Figure 4.4-20. Sediment plan view images from Stations WSW200 (A) and SE400 (B) illustrating a number of biological features present at the sediment surface. Polychaete tubes are visible in image A, while a dense tube mat together with hydroids and a small starfish are visible in image B.

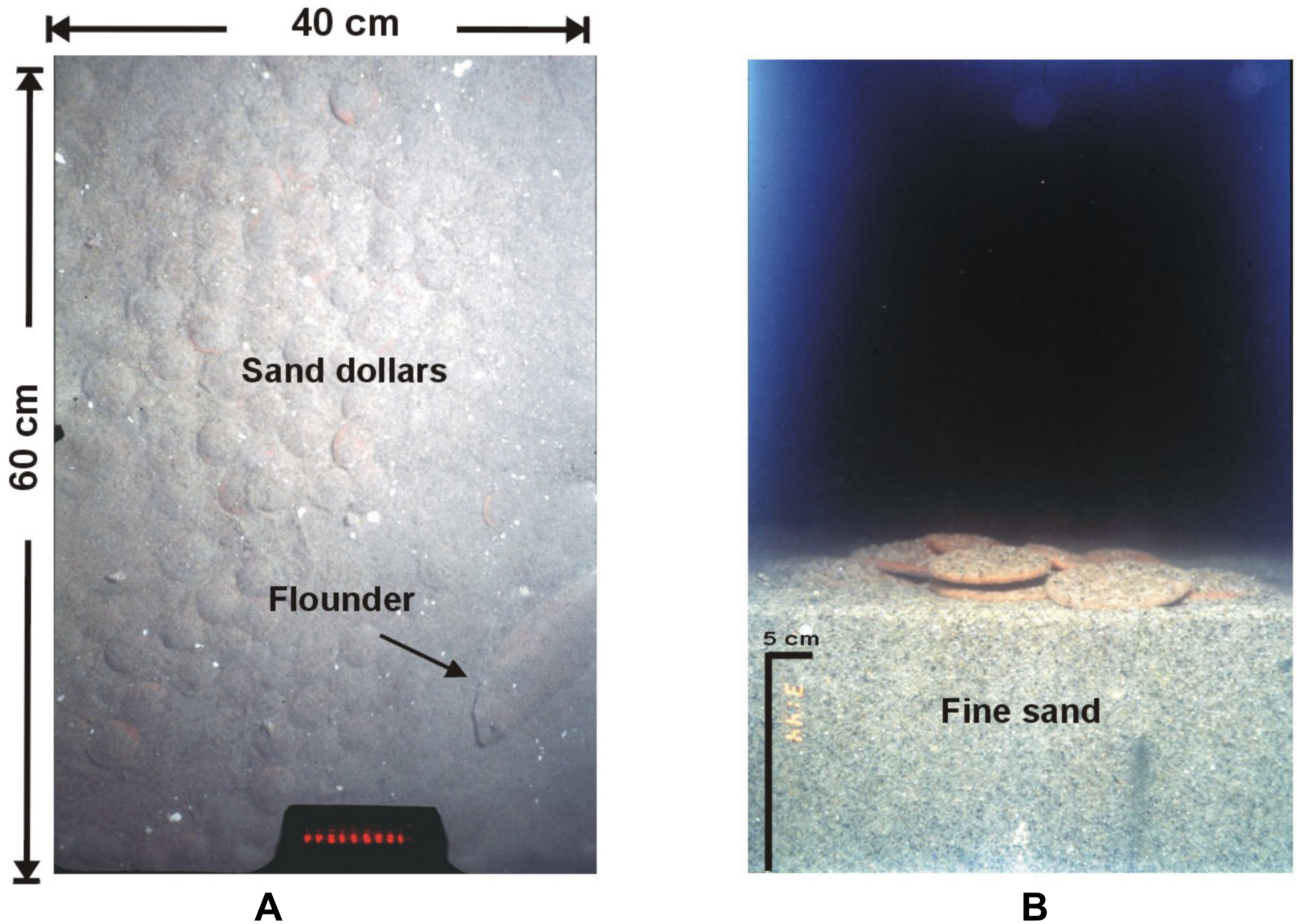


Figure 4.4-21. Plan view image (A) and corresponding REMOTS image (B) from South Reference Station SREF5 showing a dense aggregation of sand dollars at the sediment surface. A flounder is also visible at the sediment surface of image A.

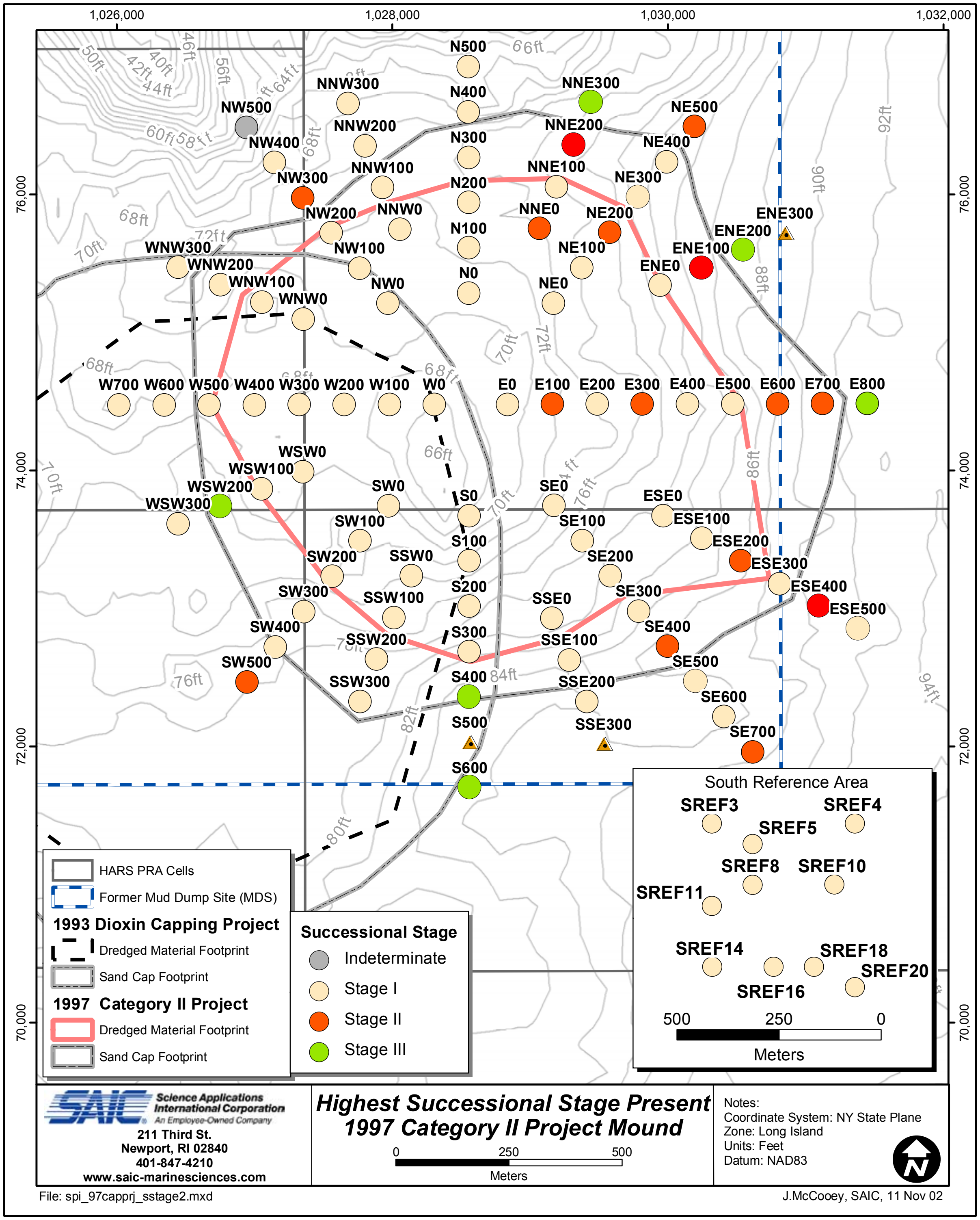


Figure 4.4-22. Highest infaunal successional stage present at the 2002 REMOTS stations over the 1997 Category II Capping Project Area.

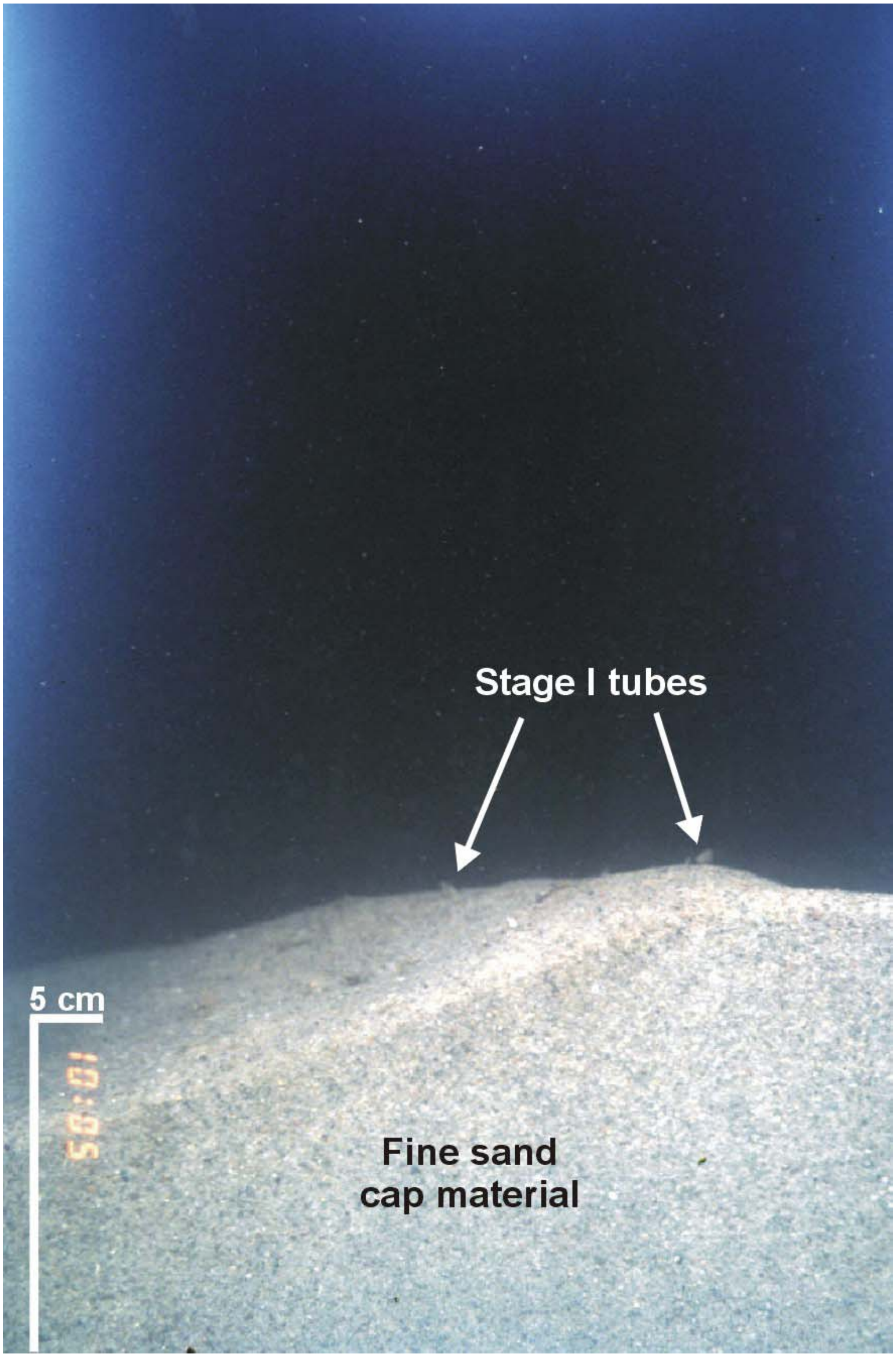


Figure 4.4-23. REMOTS image collected from Station W100 showing Stage I tubes at the surface of the sand cap material

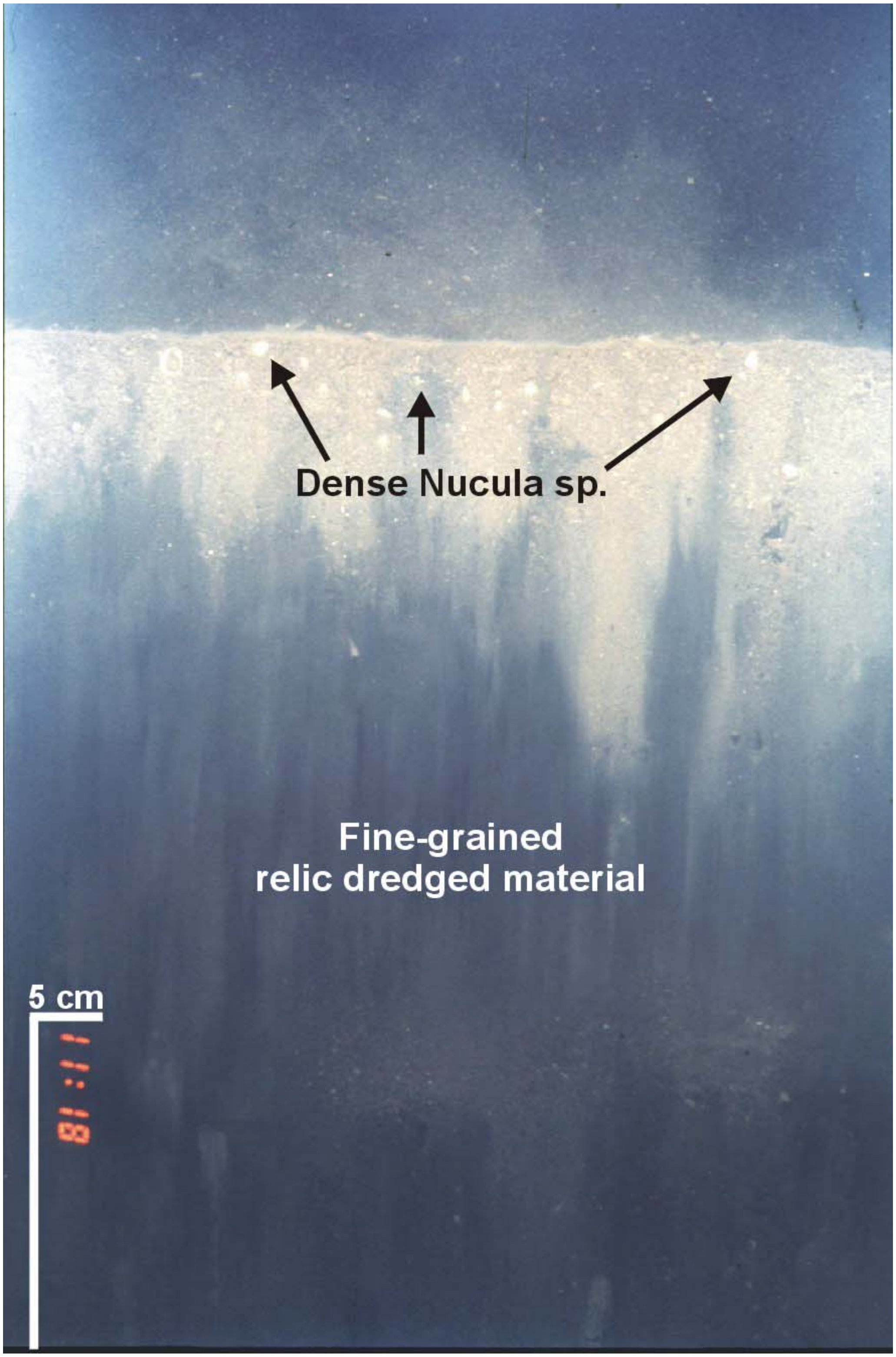


Figure 4.4-24. REMOTS image from Station S600 displaying dense Stage II shallow-dwelling bivalves (*Nucula* sp.) below the sediment surface of the fine-grained, relic dredged material.

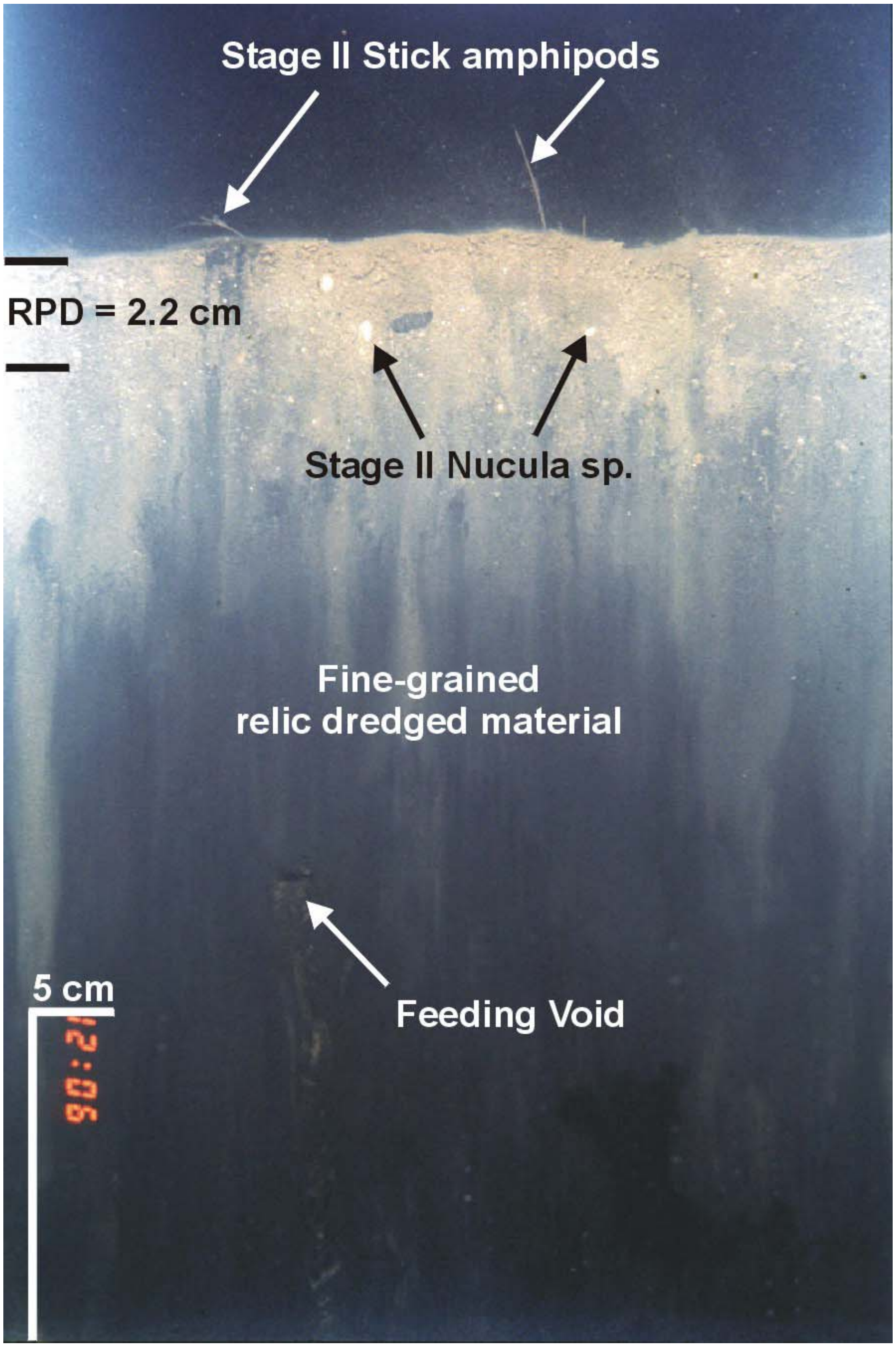


Figure 4.4-25. REMOTS image obtained from Station ENE200 illustrating a Stage II on III successional status as a result of stick amphipods at the sediment-water interface over Stage II shallow-dwelling bivalves (*Nucula* sp.) and Stage III feeding voids in the subsurface sediments. An advanced successional status and a relatively deep aRPD depth resulted in an OSI of +8 indicative of undisturbed benthic habitat quality.

The successional status at the South Reference Area included principally Stage I surface-dwelling, opportunistic polychaetes at all stations (Table 4.4-2 and Figure 4.4-22). The dominance of sand and the absence of organic-rich, fine-grained sediment at the South Reference Area precludes the establishment of a Stage III community consisting of subsurface deposit feeders.

4.4.2.2 Apparent Redox Potential Discontinuity Depths

The aRPD depth provides a measure of the apparent depth of oxygen penetration into the surface sediments and the degree of biogenic sediment mixing. The mean aRPD depths at stations within the 1997 Category II Mound ranged from 0.5 cm at Station NE400 to > 5.9 cm at Station S0, with an overall average of 3.8 cm (Table 4.4-1 and Figure 4.4-26). Overall, these are relatively deep aRPD depths, which are indicative of well-oxygenated surface sediments. At the sandy stations located within the sand cap as well as at some ambient stations, this oxidation is attributed to physical mixing of the uppermost sediment layer related to periodic bedload movement of the sand. At stations characterized by fine-grained relic dredged material (outer northern, eastern, and southern transect stations), aeration of the sediment and corresponding increases in the aRPD depth are attributed to bioturbation activities of infaunal organisms. The deepest mean aRPD depths occurred at stations characterized by high reflectance sand cap material and therefore, the aRPD depths were a function of the camera prism penetration depth (i.e., aRPD > penetration). When not detected greater than camera penetration, aRPD depths generally fell between 2 and 4 cm over the survey area (Figure 4.4-26).

Although no evidence of redox rebound intervals or sediment methane was detected in any of the REMOTS images obtained in the June 2002 survey, low apparent sediment dissolved oxygen conditions were observed within the dredged material in both replicate images of Station NE500 and in one replicate image of Station NE400. The aRPD depth was very shallow and patchy at these stations, with depths of 0.7 cm and 0.5 cm, respectively (Table 4.4-1). Black, sulfidic sediment was visible at or near the sediment surface of these stations (Figure 4.4-27). The presence of low sediment dissolved oxygen conditions at both these outer northeast transect stations suggests that the dredged material in this area may have been fairly anoxic at the time of placement with a high organic matter content.

The mean aRPD depths at stations within the South Reference Area were comparable to those observed over the 1997 Category II Mound, ranging from 2.9 cm at Station SREF16 to > 6.3 cm at Station SREF5 (Table 4.4-2 and Figure 4.4-26). The overall average of 4.5 cm is indicative of well-oxygenated surface sediments. Like the sand cap area, aRPD depths at the reference area are primarily controlled by physical movement of the seabed by sand waves. Furthermore, aRPD depths extended beyond the penetration depth of the camera prism at the majority of these sandy stations (i.e., aRPD > penetration) (Figure 4.4-8). Like the 1997 Category II Mound stations, these are conservative measurements. None of the stations occupied over the South Reference Area showed any evidence of low sediment dissolved oxygen conditions, visible redox rebounds, or methane gas bubbles.

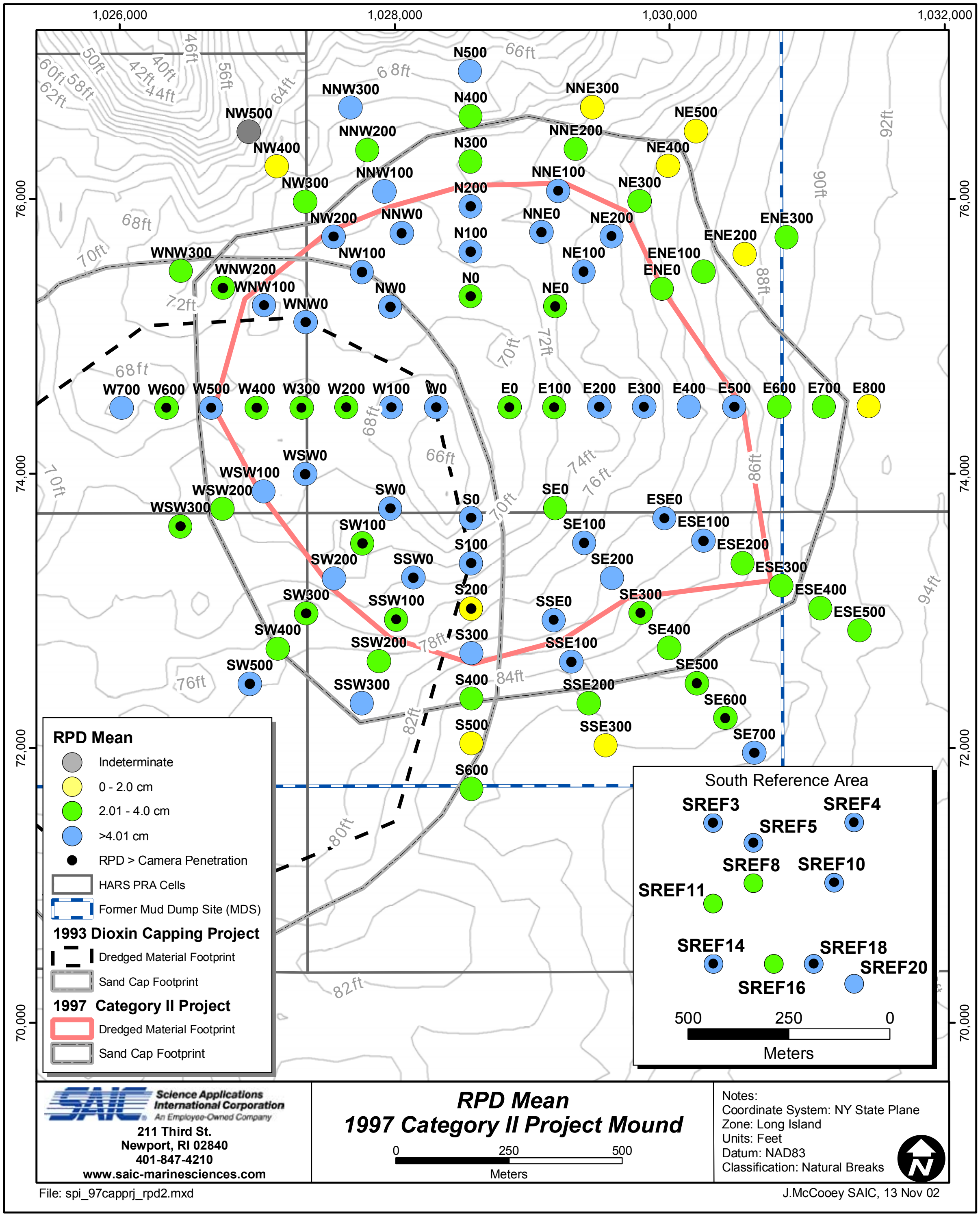


Figure 4.4-26. Average aRPD depths (cm) at the 2002 REMOTS stations over the 1997 Category II Capping Project Area.

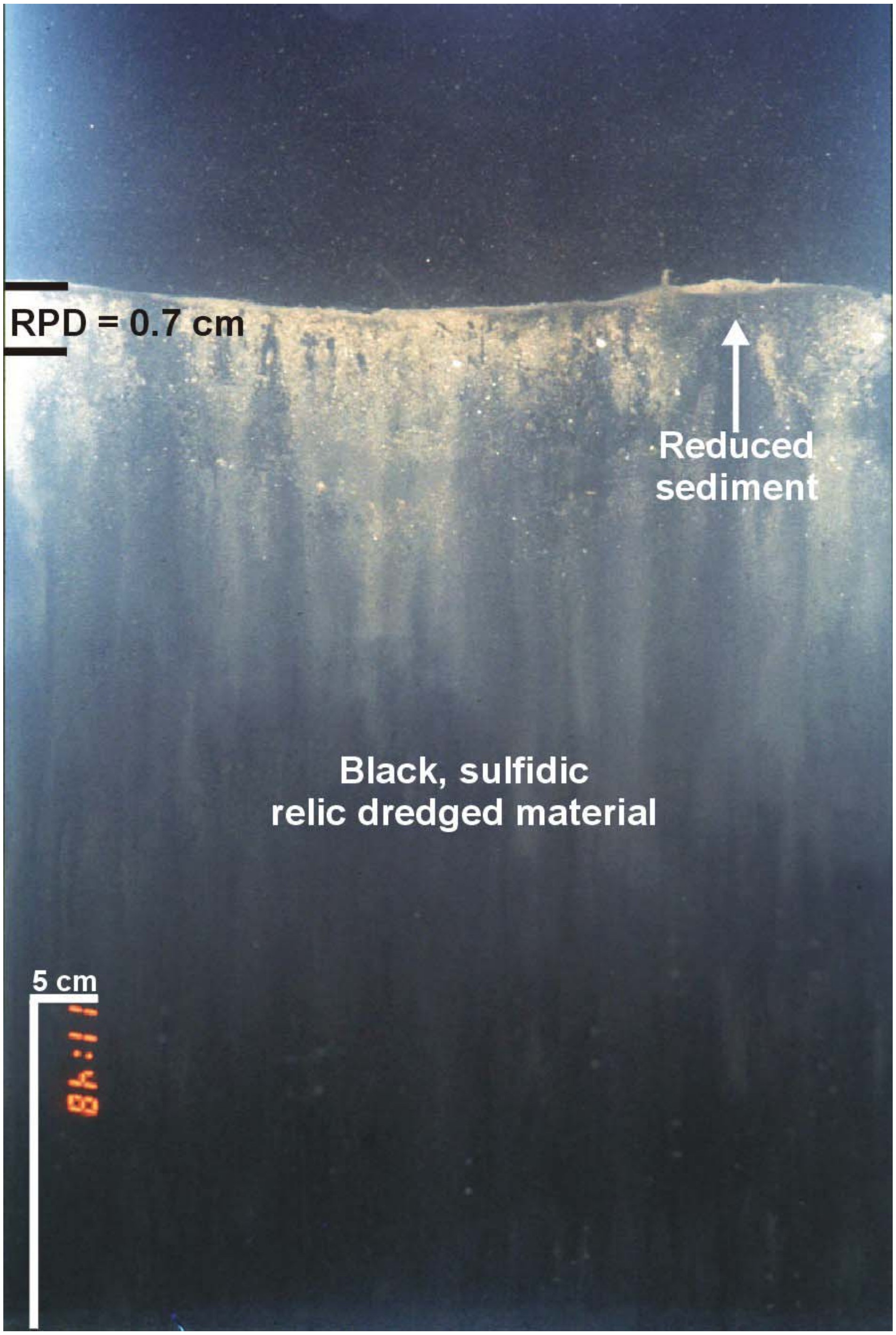


Figure 4.4-27. REMOTS image from Station NE500 showing low apparent sediment dissolved oxygen conditions within the relic dredged material due to black, sulfidic sediment near the sediment surface. A shallow aRPD depth of 0.7 cm was calculated for this replicate image and resulted in an OSI value of –2 indicative of disturbed benthic habitat quality.

4.4.2.3 Organism-Sediment Index

Mean OSI values for stations within the 1997 Category II Mound ranged from -1.0 at Station NE500 to +10.5 at Station WSW200 (Table 4.4-1 and Figure 4.4-28). The overall value of +6.5 is generally indicative of undisturbed or non-degraded benthic habitat quality. Of the 90 stations, 65 stations (72%) displayed mean OSI values > +6.0 (highly colonized or undisturbed). Despite the minimal presence of Stage III organisms, the highest OSI values were generally found among stations located on cap material, due in part to deep mean aRPD depths determined in the sand at these stations. In contrast, OSI values indicative of disturbed benthic habitat quality were detected at stations characterized by relic dredged material (Stations NE500, NE400, and SSE300). Values on the lower end of the scale (≤ +3) occurred at stations with very shallow aRPD depths, low dissolved oxygen conditions, and/or no advanced successional stages (Figure 4.4-27). High OSI values for stations positioned outside the perimeter of the sand cap typically reflected the presence of advanced Stage III infaunal assemblages (Figures 4.4-19A and 4.4-25). One station (NW500) had an indeterminate OSI value due to low prism penetration in a hard bottom.

Benthic habitat quality at the South Reference Area was identical to the 1997 Capping Project stations. Mean OSI values ranged from +5.5 at Stations SREF16 and SREF8 to +7.0 at Stations SREF3, SREF5, SREF10, SREF14, and SREF 18, with an overall average of +6.5 (Table 4.4-2 and Figure 4.4-28). The overall OSI value (+6.5) is indicative of undisturbed benthic habitat conditions. These relatively high OSI values reflect relatively deep (> 3 cm) aRPD depths and the widespread presence of Stage I organisms.

4.5 Benthic Grab Sampling

4.5.1 1997 Category II Mound Stations

A complete set of data showing all of the benthic taxa collected at the 1997 Category II Mound, 1997 Off-Mound and South Reference Area stations is provided in Appendix B. Fine sand was the dominant grain size fraction in the grab samples collected at the 1997 Category II Mound stations, ranging from 94% at Station W-200 to 72% at Station NE-100 (Table 4.5-1). There were also significant proportions of medium sand at the 1997 Category II Mound stations, ranging 3% at Station W-200 to 26% at Station NE-100 (Table 4.5-1). The proportions of other grain size fractions (e.g., silt-clay, coarse sand and gravel) were minimal at the six 1997 Category II Mound stations, generally less than about 3%. These results indicate that the cap sand comprising the surface of the 1997 Category II Capping Project mound was relatively well-sorted, consisting mainly of fine sand mixed with a minor amount of medium sand, with negligible amounts of fines and coarser material.

Organism density (number of individuals per m^2) did not vary widely among the six 1997 Category II Mound stations, ranging from 1,825 individuals/m^2 at Station NE-100 to 3,850 individuals/ m^2 at Station S-200 (Table 4.5-2). The number of taxa collected in each grab sample was also fairly comparable among the six stations, ranging from 25 to 30 (Table 4.5-2). Reflecting this overall similarity, the six stations had relatively comparable species diversity, evenness and richness values (Table 4.5-2).

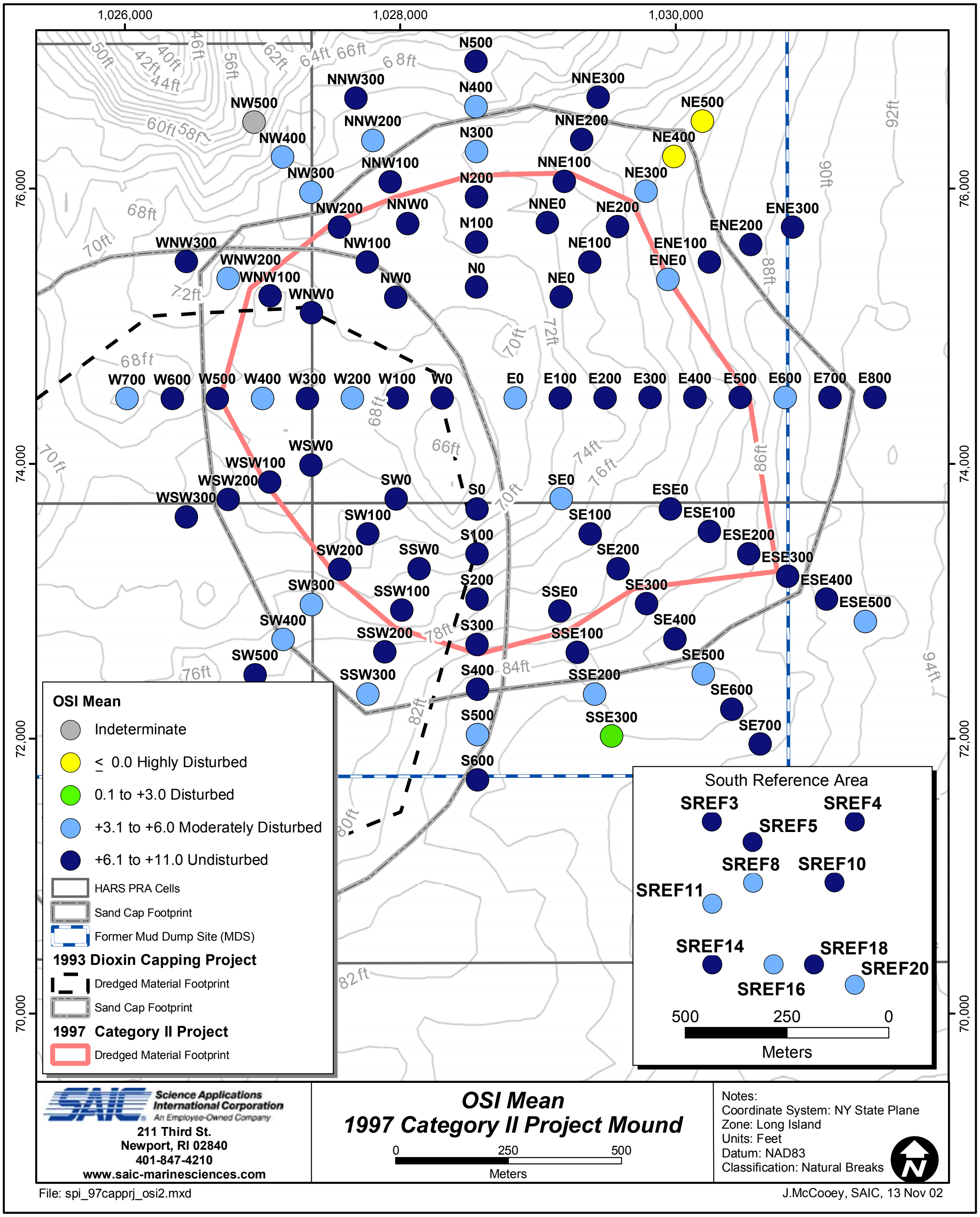


Figure 4.4-28. Average OSI values at the 2002 REMOTS stations over the 1997 Category II Capping Project Area.

Table 4.5-1.
Summary of Grain Size Analysis Results for the Benthic Grab Samples

	% Medium Sand	% Fine Sand	% Silt-clay
97 Mound Stations			
E-200	12.8	83.7	3.3
S-200	11.7	85.6	2.6
NE-100	25.8	71.9	2.2
W-200	2.8	93.9	3.3
SE-100	23.1	73.3	3.4
NW-100	10.4	87.1	2.5
97 Off-Mound Stations			
NE-300	1.9	94.0	4.1
NE-500	3.9	34.7	56.9
S-500	1.2	55.4	40.8
South-Ref Stations			
S-4	50.2	46.4	2.7
S-8	19.7	75.7	4.4
S-14	9.5	88.8	1.7

Table 4.5-2.
Summary of Benthic Community Parameters for the Six 1997 Mound Stations

	Station					
	E-200	**S-200**	**NE-100**	**W-200**	**SE-100**	**NW-100**
No. individuals/m^2	2,925	3,850	1,825	1,975	2,150	2,475
No. of taxa	27	27	25	25	29	30
Shannon-Weiner diversity (log-e)	3.02	2.48	2.82	2.49	2.91	3.02
Margelef's species richness	3.26	3.15	3.20	3.16	3.65	3.71
Pielou's evenness	0.92	0.75	0.87	0.77	0.86	0.89
Fifteen most abundant taxa for all 6 stations combined (percent of total abundance in parentheses)	Pullucistoma (LPIL) (16%) Polygordius (LPIL) (8%) Nephtys picta (7%) Diastylis polita (7%) Edotea triloba (7%) Exogone hebes (5%) Nucula proxima (5%) Spisula solidissima (4%) Chiridotea tuftsi (4%) Mancocuma stellifera (4%) Tubificidae (LPIL) (3%) Aricidea catherinae (2%) Rhynchocoela (LPIL) (2%) Spiophanes bombyx (2%) Tellina agilis (2%)					

The most abundant organism at the 1997 Category II Mound stations was the ostracod *Pellucistoma* sp. (LPIL), which accounted for 16% of the total number of individuals collected at the six stations. The numerical dominants also included several annelids, including the Stage I polychaetes *Polygordius* sp., *Exogone hebes*, and *Spiophanes bombyx*, the Stage III polychaetes *Aricidea catherinae*, and *Nepthys picta*, and Stage I oligochaetes of the Family Tubificidae (Table 4.5-2). In addition to *Pellucistoma* sp., several other arthropods were also relatively abundant, including the cumaceans *Diastylis polita* and *Mancocuma stellifera* and the isopods *Edotea triloba* and *Chiridotea tuftsi*. Finally, the bivalve molluscs *Nucula proxima* (nut clam), *Spisula solidissima* (surf clam), and *Tellina agilis* (dwarf Tellin) also were among the top 15 most abundant taxa at the 1997 Category II Mound stations (Table 4.5-2).

4.5.2 1997 Off-Mound Stations

The grain size distribution at 1997 Off-Mound Station NE-300 was similar to that at the 1997 Category II Mound stations: mainly fine sand (94%) with less than 5% of any other size fraction (Table 4.5-1). In contrast, 1997 Off-Mound Stations NE-500 and S-500 each had significant proportions of silt-clay. At Station NE-500, silt-clay was the dominant fraction at 57%, followed by fine sand at 35% and less than 4% of any other constituent (Table 4.5-1). At Station S-500, there was slightly more medium sand (55%) than silt-clay (41%; Table 4.5-1).

Organism density (number of individuals per m^2) varied widely among the three 1997 Off-Mound stations, ranging from 6,500 individuals/m^2 at Station NE-300 to 101,950 individuals/ m^2 at Station NE-500 (Table 4.5-3). This large variation in organism density was due primarily to differences in the numbers of the nut clam, *Nucula proxima.* Overall, this species was the overwhelming numerical dominant at the 1997 Off-Mound stations, accounting for 94% of all the individuals collected at these three stations (Table 4.5-3). The density of this species varied from 2,750 individuals/m^2 at Station NE-300 to 100,000 individuals/m^2 at Station NE-500. *Nucula proxima* is a common Stage II species that is relatively insensitive to sediment contamination and has been reported as one of the basic, dominant infauna of the New York Bight (Chang et al. 1992).

A relatively large number of taxa (44) were collected at Station NE-300, while comparatively few taxa (16) were found at Station NE-500 (Table 4.5-3). Reflecting the overwhelming dominance of *Nucula proxima*, Stations NE-500 and S-500 had relatively low species diversity, richness and evenness, while species richness at Station NE-300 was high (Table 4.5-3).

In addition to *Nucula proxima*, several annelids were also relatively abundant at the 1997 Off-Mound stations, including the Stage I polychaetes *Monticellina dorsobranchialis*, *Pherusa affinis*, *Cirratulidae* (LPIL), and *Cossura soyeri*, the Stage III polychaetes *Nepthys incisa*, *Levinsenia gracilis*, and *Scoletoma verrilli*, and Stage I oligochaetes of the Family Tubificidae (Table 4.5-3). Also among the top 15 numerical dominants were the ostracod *Eusarsiella zostericola*, the cumacean *Diastylis polita*, and the bivalves *Cerastoderma pinnulatum* (little cockle) and *Pita morrhuanus* (false quahog).

Table 4.5-3.
Summary of Benthic Community Parameters for the Three 1997 Off-Mound Stations

	Station NE-300	NE-500	S-500
No. individuals/m2	6,500	101,950	64,025
No. of taxa	44	16	30
Shannon-Weiner diversity	2.65	0.14	0.50
Margelef's species richness	4.90	1.30	2.62
Pielou's evenness	0.70	0.05	0.15
Fifteen most abundant taxa for all 3 stations combined (percent of total abundance in parentheses)	Nucula proxima (94%) Nephtys incisa (1%) Levinsenia gracilis (<1%) Monticellina dorsobranchialis (<1%) Scoletoma verrilli (<1%) Pherusa affinis (<1%) Cirratulidae (LPIL) (<1%) Cossura soyeri (<1%) Eusarsiella zostericola (<1%) Cerastoderma pinnulatum (<1%) Tubibificidae (LPIL) (<1%) Actiniaria (LPIL) (<1%) Pita morrhuanus (<1%) Phoronis (LPIL) (<1%) Diastylis polita (<1%)		

4.5.3 South Reference Area Stations

The grain size distribution at South Reference Area Stations S-8 and S-14 was generally similar; both were dominated by fine sand (>75%), with a moderate proportion of medium sand (10% to 20%) and less than 5% silt-clay (Table 4.5-1). At Station S-4, medium sand was the dominant fraction at slightly more than 50%, followed by a significant fine sand fraction (46%) and less than 3% silt-clay (Table 4.5-1). The combined proportions of coarse sand and gravel were less than 1% at all three stations.

Organism density at each of the three South Reference Area stations was generally comparable to that found at the 1997 Category II Mound stations, ranging from 2,400 individuals/m^2 at Station S-8 to 5,625 individuals/m^2 at Station S-14 (Table 4.5-4). The number of unique taxa found at each station ranged from 28 to 38. The most numerically abundant organisms at the three reference stations were Tubificid oligochaetes, which accounted for 16% of the total overall number of individuals (Table 4.5-4). These are generally considered pollution-tolerant, opportunistic Stage I organisms.

Among the other numerical dominants at the South Reference Area stations were several annelids, including the Stage I polychaetes *Polygordius* sp., *Monticellina dorsobranchialis*, *Exogone hebes*, and *Caulleriella* sp. J, as well as the Stage III polychaetes *Aricidea catherinae* and *Nepthys picta* (Table 4.5-4). Several arthropods were also relatively abundant, including the ostracod *Pellucist3oma* sp., the cumacean *Mancocuma stellifera*, the isopod *Chiridotea tuftsi*, the tanaid *Tanaissus psammophilus*, and the amphipods *Rhepoxynius epistomus* and *Unciola* sp. The nut clam *Nucula proxima* was also among the top 15 most abundant taxa, but at significantly lower densities than observed at the 1997 Category II Mound and 1997 Off-Mound stations (Table 4.5-4).

Shannon-Weiner diversity (H') ranged from 2.53 to 3.23 and Pielou's evenness ranged from 0.76 to 0.89 at the three reference area stations (Table 4.5-4). Reflecting the relatively high number of taxa found at Station S-4, this station had the highest species richness among the three.

4.5.4 Comparison of 1997 Category II Mound, 1997 Off-Mound, and South Reference Area Stations

4.5.4.1 Univariate Statistics

The average organism density per station at the 1997 Off-Mound stations (57,492 individuals/m^2) was considerably higher than at either the 1997 Category II Mound stations (2,533 individuals/m^2) or South Reference Area stations (3,850 individuals/m^2; Table 4.5-5). This difference is due largely to the disproportionately high numbers *Nucula proxima* at several of the 1997 Off-Mound stations. The uneven distribution of this species among the three 1997 Off-Mound stations is reflected in the high standard deviation of ±48,059 individuals/m^2 (Table 4.5-5).

Table 4.5-4.
Summary of Benthic Community Parameters for the Three South Reference Area Stations

	Station S-4	S-8	S-14
No. individuals/m2	3,525	2,400	5,625
No. of taxa	38	30	28
Shannon-Weiner diversity	3.23	2.93	2.53
Margelef's species richness	4.53	3.73	3.13
Pielou's evenness	0.89	0.86	0.76
Fifteen most abundant taxa for all 5 stations combined (percent of total abundance in parentheses)	Tubificidae (LPIL) (16%) Exogone hebes (LPIL) (10%) Polygordius (LPIL) (8%) Pellucistoma (LPIL) (8%) Nepthys picta (6%) Mancocuma stellifera (4%) Caulleriella sp. J (4%) Aricidea catherinae (3%) Rhepoxynius epistomus (3%) Rhynchocoela (LPIL) (2%) Tanaissus psammophilus (2%) Monticellina dorsobranchialis (2%) Nucula proxima (2%) Unciola (LPIL) (2%) Chiridotea tuftsi (2%)		

Table 4.5-5.
Comparison of Benthic Community Parameters for
the 1997 Mound, 1997 Off-Mound, and South Reference Area Stations

	1997 Mound Stations	1997 Off-Mound Stations	South Reference Area
Number of stations (samples)	6	3	3
Avg. no. individuals/m^2 per station (± 1 s.d.)	2,533 (± 755)	57,492 (± 48,059)	3,850 (± 1,637)
Avg. no. taxa per station (± 1 s.d.)	27 (± 2)	30 (± 14)	32 (± 5)
Avg. Shannon-Weiner diversity (± 1 s.d.)	2.79 (± 0.25)	1.1 (± 1.4)	2.9 (± 0.4)
Avg. Pielou's evenness (± 1 s.d.)	0.84 (± 0.07)	0.30 (±0.35)	0.84 (± 0.07)
Avg. Margelef's species richness (± 1 s.d.)	3.36 (± 0.25)	2.94 (± 1.82)	3.80 (± 0.70)

The three stations groups were roughly comparable in terms of the average number of taxa per station (range of 27 to 32), but there was a high degree of variability in this parameter among the three 1997 Off-Mound stations (Table 4.5-5). Average species richness, evenness and diversity were also considerably lower at the 1997 Off-Mound stations, while the 1997 Category II Mound and South Reference Area stations were roughly comparable with respect to these parameters. The lower average species richness, diversity and evenness at the 1997 Off-Mound stations are due to the disproportionately high numbers of *Nucula proxima* at these stations compared to the other two station groups.

Ten of the fifteen taxa that were numerically dominant at the 1997 Category II Mound stations were also among the fifteen most abundant taxa at the South Reference Area stations. The list of abundant taxa common to both areas includes: *Pellucistoma* sp., *Polygordius* sp., *Nephtys picta*, *Exogone hebes*, *Nucula proxima*, *Chiridotea tuftsi*, *Mancocuma stellifera*, Tubificidae, *Aricidea catherinae* and Rhynchocoela. While these taxa were among the most abundant at both the 1997 Category II Mound and South Reference Area stations, they occurred in different relative proportions in each area. The 1997 Off-Mound stations had fewer dominant taxa in common with the other two areas: only five of the fifteen most abundant taxa at the 1997 Off-Mound stations were also among the dominants at either the 1997 Category II Mound or reference area stations.

4.5.4.2 Multivariate Statistics

In both the cluster analysis dendrogram (Figure 4.5-1) and the two-dimensional nMDS plot (Figure 4.5-2), the following three station groups are identified: 1) a group consisting of 1997 Off-Mound Stations NE-500 and S-500, 2) a group consisting of 1997 Off-Mound Station NE-300 and 1997 Category II Mound Station S-200, and 3) a group consisting of the three South Reference Area stations and the five remaining 1997 Category II Mound stations. The stations falling within each group are considered to have benthic community structure more similar to each other than to the stations comprising the other two groups. The degree of similarity between the two stations comprising the first group (Off-Mound Stations NE-500 and S-500) was relatively high (67%), reflecting the dominance of the bivalve *Nucula proxima* at these two stations. The Bray-Curtis similarity index value of 49% between the stations comprising the second group (NE-300 and S-200) indicates only a moderate degree of similarity in community structure between the two. Finally, the three South Reference Area stations and the five remaining 1997 Category II Mound stations (E-200, NE-100, W-200, NW-100 and SE-100) had community structure more similar to each other than to the other two station groups, the Bray-Curtis similarity value linking these stations was only about 40% (Figure 4.5-1).

The results of the ANOSIM test of significance are summarized in Table 4.5-6. The global test of the null hypothesis “no significance difference in benthic community structure among the three station groups” resulted in a R-statistic of 0.73 at a significance level of 0.1%. This value, which resulted in rejection of the null hypothesis, indicates that there was some degree of overlap but generally different community structure among the three station groups (i.e., between the 1997 Category II Mound, 1997 Off-Mound and South Reference Area stations).

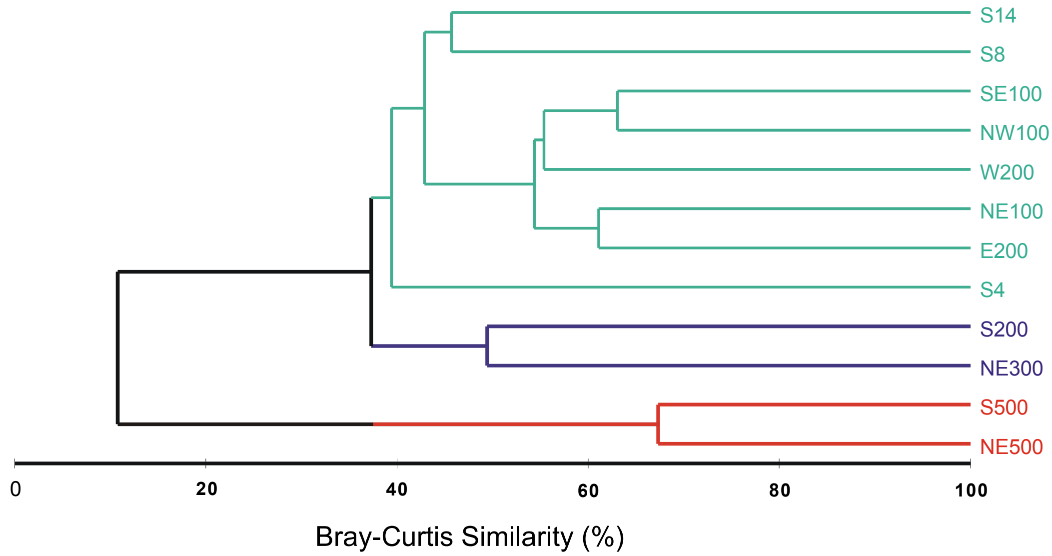


Figure 4.5-1. Dendrogram for hierarchical clustering of the 1997 Mound, 1997 Off-Mound, and South Reference Area stations based on Bray-Curtis similarity. Different colors indicate the three station groups identified at roughly the 40% Bray-Curtis similarity level.

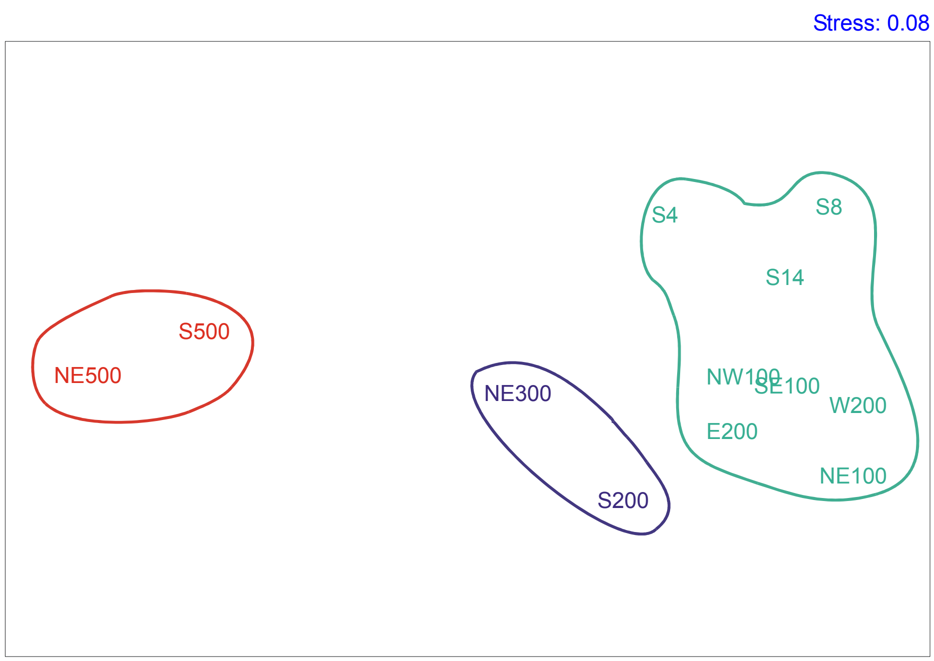


Figure 4.5-2. Two-dimensional nMDS plot of the 1997 Category II Mound and the South Reference Area Stations based on Bray-Curtis similarity. Station groups from the cluster analysis are circled. The stress value of 0.08 indicates only a minor and inconsequential amount of distortion in this 2-dimensional presentation of the station positions.

Table 4.5-6.
Results of the ANOSIM Test
(Null Hypothesis = "no significant difference in benthic community structure among/between the station groups")

Test	R-statistic	Significance level (%)	Conclusion[1]
Global test	0.73	0.1	s
Pairwise comparisons:			
Reference stations versus 1997 Mound stations	0.62	2.4	s
Reference stations versus 1997 Off-Mound stations	0.85	10.0	s
1997 Mound versus 1997 Off-Mound stations	0.87	1.2	s

[1] The letter "s" indicates a significant difference exists among/between groups and the null hypothesis is rejected. An R statistics of >0.75 indicates a strong separation or large difference in overall benthic community structure among/between groups, while 0.75>R>0.25 indicates varying degrees of overlap but generally different community structure among/between groups.

Following the global ANOSIM test, a series of pairwise comparisons were made. These tests showed there were significant differences between each possible pair of station groups (Table 4.5-6). The strongest differences existed between the 1997 Off-Mound stations and the other two station groups (R-statistics of 0.85 and 0.87). The main reason for this difference was the extremely high numbers of *Nucula proxima* at the 1997 Off-Mound stations compared to the other two station groups, as well as higher numbers of several Stage III polychaetes (e.g., *Nephtys incisa*, *Levinsenia gracilis*, and *Scoletoma verrilli*). The 1997 Category II Mound stations and the South Reference Area stations also had significantly different benthic community composition, although the R-statistic of 0.62 indicates some degree of overlap between the two. These two station groups shared many of the same dominant taxa, but at significantly different densities.

4.6 Core Descriptions and Imagery

This section presents descriptions of the cores based on visual observations and photographs. All of the cores met the project criteria of a minimum length of six feet (183 cm). Core photographs with detailed descriptions are provided in Appendix C-1.

The material observed in this suite of cores was classified as either sand cap material or underlying dredged material. The specific characteristics of each of these material units are discussed in detail below. Visual observations made by SAIC laboratory technicians, discrete core data measurements, and down-core geotechnical profiles were consulted in order to arrive at the material type classifications presented.

4.6.1 Sand Cap

The sand cap material was a mix of primarily fine and medium sand with some portions of coarse sand. There was a small proportion (3%) of clay in the cap material. In general the sand ranged from dark gray to tan in color. The transition between the cap and dredged material units was clearly evident, as seen in the core images (Appendix C-1).

All 14 cores were collected within the cap boundary footprint (Figure 2.7-1). All cores contained a sand cap layer. Cap thickness was variable ranging from 90 cm in Core 97Q to 264 cm in Core 97P (Table 4.6-1). The overall average sand cap thickness for the 14 cores was 174 cm (Table 4.6-1). Two cores contained slightly less than 1 m of cap material, 97Q and 97B. These cores contained 90 and 97 cm of cap, respectively. Eight of the 12 cores contained greater than 1.5 m of sand cap. The overall cap thickness of the 2002 cores was similar to the results from the May 1997 coring survey at the same stations (Table 4.6-1). Differences between the two surveys are attributed to small-scale spatial variability in cap thickness across the mound. Overall, the 2002 results indicate little significant change in overall cap thickness since the previous May 1999 survey.

The 14 coring stations were identical to historically sampled stations. When cap thickness of the 2002 survey is compared to that of the last survey (May 1999), eight cores indicated either the same or more cap material present (97A, 97C, 97D, 97L, 97O, 97P, 97R, and 97S). Cores 97B, 97E, 97Q, 97T, 97U and 97V indicated a loss of material (Table 4.6-1). Previous coring surveys

Table 4.6-1.
Measured Thickness of the Sand Cap Layer in the 2002 and the 1999 Cores.
For comparative purposes, measured sand cap thickness values
for the cores obtained in the previous coring survey of May 1999 are also shown.

Core Station ID	2002 Total Core Length (cm)	2002 Sand Cap Thickness (cm)	1999 Sand Cap Thickness (cm)
97A	288	106	106
97B	296	97	140
97C	234	190	134
97D	282	206	126
97E	283	143	168
97L	280	258	221
97O	286	260	148
97P	264	264	190
97Q	294	90	132
97R	294	152	92
97S	280	223	158
97T	292	130	150
97U	282	113	151
97V	291	203	229
Average	**282**	**174**	**153**

at the 1997 Category II Mound have shown similar spatial variability in cap thickness, both among replicate cores and at similar locations through time (SAIC 1998c, SAIC 2000).

4.6.2 Dredged Material

Overall, the dredged material unit was composed of fine-grained black, brown, or dark gray clayey silt material with some trace amounts of fine and medium sand. Large pieces of shell, generally oyster and blue mussel, were present in the dredged material unit in a majority of the collected cores. Observed variations in color and texture are typical of the project-dredged material, as noted in previous surveys (SAIC 1998b, 1998d), and are attributed to its natural variability.

Of the 14 cores collected, half contained more than 1 m of dredged material and none reached ambient seafloor due to the length of the cores and the thickness of cap material. On average each core contained 108 cm of dredged material, with none present in Core 97P. Core 97Q contained the most dredged material, 204 cm, due to the relatively limited amount of cap retained in the core. Because none of the cores were deep enough to penetrate past the dredged material into the ambient sediment, the measurements of dredged material thickness presented here underestimate the thickness of dredged material.

Overall, the dredged material detected in the sediment vibracores was well consolidated and did not appear to have changed significantly since the previous survey. Mottled black and tan sand was frequently observed in the cores. Mottling is a descriptive term used to describe color variations of the sediment. Mottling was primarily observed in the cap directly above the dredged material or the interface of cap and dredged material. In some cases mottling was present throughout the entire cap. Mottling within the cap is frequently associated with pore water release as underlying dredged material consolidates.

4.7 Geotechnical Analysis of Core Subsamples

Geotechnical data for the discrete samples collected within each core are presented in Appendix C-2 and C-3. Summary statistics for the geotechnical parameters analyzed in the cap and dredged material units are presented in Tables 4.7-1 and 4.7-2, and discussed in the following sections.

4.7.1 Water Content

The water content of the cap material was uniform throughout all of the cores. In general cap material contained a water content between 19 and 23%. Overall, the average water content was 21 ± 1.5% (Table 4.7-1). The standard deviation, and coefficient of variation (7%) indicate consistent water content values throughout the cap material unit. All of the samples were collected from sand, thus the inherently low water content reflects the relative inability of sand to hold moisture.

Water content in the dredged material unit ranged from 18 to 79%, with an average water content of 56 ± 13% (CV=23%; Table 4.7-2). The standard deviation, and coefficient of variation (23%) indicate variability in water content values throughout the dredged material unit. The inherent ability of a sediment type to hold water is based on the sediment particle size. Finer-grained

Table 4.7-1.
Summary of Physical Properties of the Cap Material Based on Core Subsamples Collected in 2002

	CAP MATERIAL					
	Average	**Standard Deviation**	**Coefficient of Variation (%)**	**Minimum**	**Maximum**	**Sample Count**
Gravel (%)	0.4	0.5	-	0.0	1.4	16
Coarse Sand (%)	1.1	0.7	-	0.1	2.6	16
Medium Sand (%)	20.9	6.2	29.6	11.7	36.0	17
Fine Sand (%)	76.8	7.2	9.4	57.8	86.9	16
Silt (%)	0.8	-	-	-	-	1
Clay (%)	3.2	-	-	-	-	1
Passing No. 200 (%)	0.5	0.2	-	0.2	0.7	15
Water Content (%)	21.3	1.5	7.0	19.0	23.0	15
Bulk Density* (g/cc)	1.8	0.0	2.1	1.7	2.0	15
Specific Gravity -	na	na	na	na	na	0
Shear Strength kPa	na	na	na	na	na	0
USCS Symbol(s)	SP					15

*Bulk Density based on wet weight

**Water Content corrected for 35 ppt salinity

CV (%) calculated for >20%

Table 4.7-2.
Summary of Physical Properties of the Dredged Material Based on Core Subsamples Collected in 2002

	DREDGED MATERIAL					
	Average	Standard Deviation	Coefficient of Variation (%)	Minimum	Maximum	Sample Count
Gravel (%)	1.1	3.5	-	0.0	13.3	14
Coarse Sand (%)	0.9	1.7	-	0.0	5.0	14
Medium Sand (%)	5.3	7.9	-	0.8	29.1	14
Fine Sand (%)	14.9	6.3	-	7.8	29.3	14
Silt (%)	43.7	11.4	26.2	8.7	54.8	14
Clay (%)	34.1	7.3	21.4	15.0	43.0	14
Passing No. 200 (%)	-	-	-	-	-	-
Water Content (%)	56.4	12.9	22.9	18.0	79.0	26
Bulk Density* (g/cc)	1.7	0.1	4.4	1.6	1.9	25
Specific Gravity -	2.7	0.0	0.4	2.7	2.7	13
Shear Strength kPa	37.6	13.0	34.7	10.3	63.6	13
USCS Symbol(s)	CL (2), ML (11), SC (1)					13

*Bulk Density based on wet weight

**Water Content corrected for 35 ppt salinity

CV (%) calculated for >20%

sediments such as silts and clays are generally associated with higher water content values. Sediment samples containing clays tend to have higher water contents while samples containing coarser material or sand tend to have lower water content values. The variability noted in these samples is indicative of fine-grained dredged sediments.

The water content profiles in Appendix C-4 reflect the two types of sediment found in the cores (cap material versus underlying dredged material). Individual water content results, per subsample location, are included in Appendix C-3.

4.7.2 Bulk Density

In general, bulk density is inversely proportional to water content. During the process of consolidation, interstitial water is forced from pore spaces, and that volume is then replaced by sediment. This results in more sediment being present within an equal sample volume, thereby increasing the material's bulk density. Within the cap material, the average bulk density was 1.8 g/cc, with a range of 1.7 to 2.0 g/cc (Table 4.7-1). The bulk density for cap material has not changed since the last survey. Within the dredged material unit, the average bulk density was 1.7 ± 0.1 g/cc, and ranged from 1.6 to 1.9 g/cc (Table 4.7-2). Unlike water content, the bulk density values do not reflect a clear distinction between cap material and dredged material in the down core profiles (Appendix C-4).

4.7.3 Grain Size

Grain size measurements indicated a sharp distinction between the sand cap and the underlying finer grained dredged material (Appendix C-2). Within the cap material, fine sand was the major mode (average 77%) and showed the least variation among cores (CV=9%; Table 4.7-1). Medium sand (average 21%; CV=30%) was also a significant component of the cap. Silt and clay combined made up only about 4% of the cap material.

The dredged material had a major mode of silt (average 44%) and clay (average 34%, Table 4.7-2). Fine sand (average 15%) and medium sand (average 5%) fractions were also significant components of the dredged material. Gravel and coarse sand were present at less than 2% frequency. Variability among cores was relatively high for silts and clay with CV=26% and CV=21%, respectively.

4.7.4 Specific Gravity

Specific gravity was only analyzed for one sample per core for the dredged material unit. Specific gravity is used in calculating the phase relationships of soils, that is, the relative volumes of solids to water and air. Specific gravity typically refers to naturally occurring mineral particles that are not readily soluble in water. The specific gravity was 2.7 for every sample analyzed (Table 4.7-2). Individual specific gravity results, per subsample location, are provided in Appendix C-3. These results are consistent with the average specific gravity value of 2.6± 0.3 during the May 1999 survey.

4.7.5 Shear Strength

Shear strength measurements were only made on the dredged material unit of the cores. The high sand contents of the cap material made it impossible to obtain valid shear strength measurements. Therefore, Core 97P (containing all sand) was not analyzed for shear strength. The dredged material unit was highly variable in shear strength (CV=35%), with a range from 10 to 66 kPa and an average of 38±13 kPa (Table 4.7-2). The highest shear strength was in Core 97S in the silty dredged material immediately below the cap material, while the weakest material was noted in Core 97V in an area below the cap described as black, moist firm clay and sand. Core 97V contained bands of sand intermixed with bands of clay below the noted cap and dredged material interface. Individual shear strength values for the cores are included in Appendix C-5.

4.7.6 USCS Classification

Based on the Unified Soil Classification System (USCS), the classification for the sand cap (Table 4.7-1) was uniformly SP (poorly sorted sand). Classification of the dredged material indicated variability within this unit. Eleven samples of the black clayey silt (dredged material) were classified as ML or black silt. Two samples consisted of sandy lean clay (CL). Only one sample was noted as SC or sand with clay.

4.8 Chemical Analysis of Core Subsamples

The following sections present the chemical results for the summer 2002 coring survey over the 1997 Category II Mound. As previously described, the sand cap material in six cores was sampled for TOC, dioxin and furan analyses at 10 and 30 cm above the sand cap/dredged material interface. Likewise, the underlying dredged material in the same six cores was sampled at 10 and 30 cm below the sand cap/dredged material interface.

4.8.1 Total Organic Carbon (TOC)

TOC concentrations in the core samples ranged from <0.1 (less than the detection limit) to 1.9% (Table 4.8-1). The cap material had the lowest TOC concentrations. Over half of the samples collected from the cap material contained TOC values below the detection limit. The samples collected from the cap that did contain detectable TOC had values of 0.12%, 0.13% and 0.24%. Overall, the TOC values from the cap material were comparable to values measured in the May 1999 survey.

The dredged material unit for this survey had TOC values ranging from 0.6 to 1.9%, with an overall average value of 1.4% ± 0.4. In the May 1999 survey, TOC values for dredged material ranged from 0.4 to 1.7%. Again, the TOC values of the dredged material for the 2002 survey were comparable to those of the May 1999 coring survey of the 1997 Category II Mound.

4.8.2 Dioxin and Furan Concentrations

Sediment concentrations of all measured PCDDs/PCDFs, including congener data, are presented on a dry weight basis for the six cores in Appendix C-6. Samples were collected from both the sandy cap material as well as the underlying dredged material. Results are summarized based on these two classifications in Tables 4.8-2 and 4.8-3.

Table 4.8-1.
Total Organic Carbon Concentrations in Core Subsamples for the 2002 Monitoring Survey

Core	Sample ID[1]	TOC (%, dry wt.)	Material Type
97B	97B+67	<0.1[2]	sand cap
	97B+87	<0.1	sand cap
	97B-107	1.3	dredged material
	97B-127	1.9	dredged material
97D	97D+176	0.24	sand cap
	97D+196	<0.1	sand cap
	97D-216	1.6	dredged material
	97D-236	0.6[3]	dredged material
97E	97E+113	<0.1	sand cap
	97E+133	0.12	sand cap
	97E-153	1.2	dredged material
	97E-173	1.4	dredged material
97Q	97Q+60	<0.1	sand cap
	97Q+80	<0.1	sand cap
	97Q-100	1.2	dredged material
	97Q-120	0.64	dredged material
97R	97R+122	0.13	sand cap
	97R+142	<0.1	sand cap
	97R-162	1.9[3]	dredged material
	97R-182	1.2	dredged material
97U	97U+103	<0.1	sand cap
	97U+83	<0.1	sand cap
	97U-123	1.0	dredged material
	97U-143	1.2	dredged material

[1]indicates samples collected above (+) and (-) below the sand cap dredged material interface
[2] <0.1 is less than the detectable limit.
[3] Values represent average concentration based on triplicate analysis.

Table 4.8-2.
Summary of Dioxin and Furan Concentrations in the
Cap Material for the 2002 Survey of the 1997 Category II Mound

Compound Name	Average	Stdev.	Minimum	Maximum	Sample Count
2,3,7,8-TCDF (furan)	0.10	0.00	0.09	0.1	12
2,3,7,8-TCDD (dioxin)	0.10	0.01	0.09	0.115	12
1,2,3,7,8-PeCDF	0.48	0.02	0.42	0.5	12
2,3,4,7,8-PeCDF	0.48	0.02	0.42	0.5	12
1,2,3,7,8-PeCDD	0.48	0.02	0.42	0.5	12
1,2,3,4,7,8-HxCDF	0.48	0.02	0.42	0.5	12
1,2,3,6,7,8-HxCDF	0.48	0.02	0.42	0.5	12
2,3,4,6,7,8-HxCDF	0.48	0.02	0.42	0.5	12
1,2,3,7,8,9-HxCDF	0.48	0.02	0.42	0.5	12
1,2,3,4,7,8-HxCDD	0.59	0.38	0.42	1.8	12
1,2,3,6,7,8-HxCDD	0.48	0.02	0.42	0.5	12
1,2,3,7,8,9-HxCDD	0.48	0.02	0.42	0.5	12
1,2,3,4,6,7,8-HpCDF	0.78	1.05	0.42	4.1	12
1,2,3,4,7,8,9-HpCDF	0.48	0.02	0.42	0.5	12
1,2,3,4,6,7,8-HpCDD	2.25	5.60	0.42	20	12
OCDF	2.22	4.34	0.85	16	12
OCDD	20.80	40.96	4.60	150	12
TEC	**0.06**	**0.16**	**0.00**	**0.58**	**12**

Table 4.8-3.
Summary of Dioxin and Furan Concentrations in the
Dredged Material for the 2002 Survey of the 1997 Category II Mound

Compound Name	Average	Stdev.	Minimum	Maximum	Sample Count
2,3,7,8-TCDF (furan)	2.04	3.03	0.32	8.4	12
2,3,7,8-TCDD (dioxin)	3.60	6.04	0.40	22	12
1,2,3,7,8-PeCDF	21.65	42.59	0.49	150	12
2,3,4,7,8-PeCDF	2.18	3.67	0.25	13	12
1,2,3,7,8-PeCDD	1.09	1.37	0.25	4.9	12
1,2,3,4,7,8-HxCDF	3.45	5.12	0.25	16	12
1,2,3,6,7,8-HxCDF	2.85	5.11	0.25	16	12
2,3,4,6,7,8-HxCDF	1.73	2.48	0.25	8.4	12
1,2,3,7,8,9-HxCDF	0.96	1.34	0.25	4.9	12
1,2,3,4,7,8-HxCDD	1.24	1.69	0.25	4.9	12
1,2,3,6,7,8-HxCDD	2.38	4.23	0.25	15	12
1,2,3,7,8,9-HxCDD	1.69	2.15	0.49	7.2	12
1,2,3,4,6,7,8-HpCDF	23.33	40.75	1.30	140	12
1,2,3,4,7,8,9-HpCDF	1.88	3.15	0.25	11	12
1,2,3,4,6,7,8-HpCDD	43.25	63.46	16.00	240	12
OCDF	34.29	60.23	2.20	210	12
OCDD	897.50	552.78	540.00	2500	12
TEC	**6.60**	**11.18**	**1.00**	**41**	**12**

All 12 of the samples collected from the cap material contained dioxin values below the Level of Detection (LOD). Averages were calculated for samples with no associated value (not detected or below the detection limit) by using a value of half of the LOD. The dioxin values ranged from 0.095 to 0.115 pptr, with an average value of 0.1 pptr ± 0.01 (Table 4.8-2).

Furan values for these same 12 cap samples were also below the LOD or the calibration range. Overall, the furan concentration values in the cap material ranged from 0.085 to 0.1 pptr with an average of 0.10 pptr (Table 4.8-2). Overall, the lack of any detectable concentrations of furan or dioxin above the required detection limit of 1.0 pptr provides evidence for negligible vertical transport of these compounds into the cap material.

Twelve samples were collected from the dredged material, measured concentrations of dioxin ranged from 0.4 to 22 pptr with an average value of 3.6 pptr ± 6.04 (Table 4.8-3). Three samples indicated values greater than the average: 97U-123 (5.9 pptr), 97U-143 (22 pptr), and 97B-127 (4.3 pptr). The samples collected from the cap material for all of these cores did not indicate any elevation in dioxin concentrations. The higher values detected in the dredged material were expected and are not unusually high for this capped mound.

The detected concentrations of furan in the dredged material ranged from 0.32 to 8.4 pptr, with an average of 2.04 pptr ± 3.03(Table 4.8-3). Three samples had values greater than 1pptr: 97U-123 (2.6 pptr), 97U-143 (8.4 pptr), and 97R-162 (8.4 pptr). The samples collected from the cap material for all of these cores did not indicate any elevation in furan concentrations.

4.8.3 Toxic Equivalent Concentrations (TEC)

The concentrations of congeners in the sediments have been expressed in terms of 2,3,7,8-TCDD Toxic Equivalents Concentrations (TECs; Safe 1990) for each sediment sample (Appendix C-6). In general, TEC values mimic those of dioxin. TECs are summarized for both the cap and dredged material units in Tables 4.8-2 and 4.8-3. The cap material had the lowest average TEC (0.06 ± 0.16 pptr). The silty dredged material had the highest average TEC value, along with higher variability (6.6 ± 11 pptr). The average TEC values for the 1999 survey were 0.90 ± 0.51 pptr in cap material and 4.3 ± 3.4 pptr in the dredged material. Therefore, the values detected in the 2002 survey are comparable to these earlier results.

5.0 DISCUSSION

The summer 2002 monitoring of the 1997 Category II Capping Project utilized a suite of survey techniques, including precision bathymetry, side-scan sonar, sub-bottom profiling, REMOTS sediment-profile imaging, benthic grab sampling and coring. These same techniques have been utilized at various times over the past five years to monitor seafloor conditions prior to, during, and following the construction of the capped mound. In particular, after the capping operation was completed in January 1998, postcap monitoring surveys were conducted in 1998 and 1999 to evaluate cap stability (Figure 1.1-3).

The summer 2002 survey therefore represents the latest in a succession of postcap monitoring events designed to address the following three questions:

1) Has the cap remained stable following its original construction in January 1998?
2) Has the cap remained effective at isolating the dioxin and furan known to be present at low levels in the underlying dredged material?
3) Has the surface of the cap become recolonized by benthic organisms in a manner consistent with expectations?

The following discussion is organized around these three questions.

5.1 Long-Term Cap Stability

Following the completion of the capping operation in January 1998, precision bathymetric surveys were conducted over the 1997 Category II Capping Project Mound in February 1998, April 1998, and April 1999 as part of the postcap monitoring program (Figure 1.1-3). This has allowed a series of depth difference maps to be prepared, whereby the results of one bathymetric survey are compared to the results of the preceding survey to determine whether or not there were any significant changes in mound topography in the interim time period. If depths over the mound were found to be increasing over time, it would be taken as an indication of sand cap erosion or mound consolidation. The depth difference results between the April 1998 (postcap) and April 1999 (one-year postcap) bathymetric surveys are summarized in Figure 5.1-1 (SAIC 1999). This figure shows that as of the last bathymetric survey of April 1999, there had been no significant changes in depth detected over the capped mound since the April 1998 bathymetric survey that had occurred soon after the completion of the capping operation in January 1998.

The results of the summer 2002 bathymetric survey were compared to those of the previous bathymetric survey of April 1999. Disposal operations ceased over the 1993 Dioxin and 1997 Category II Mounds in January 1998; therefore, no significant deposition was expected. However, the preliminary depth difference map suggested that depths were about 1.2 feet shallower in 2002 over most of the 1997 Category II Mound compared to the previous April 1999 survey (Figure 4.1-2). There were no strong reasons such as nearby disposal operations or adjacent erosion to support the uniform deposition over the mound. Therefore, the uniformity of the apparent depth change over the entire surface of the 1997 Category II Mound suggests that it is likely due to a consistent offset in one or both of the datasets. The "corrected" depth difference map (Figure 4.1-3) shows only random positive and negative depth differences that

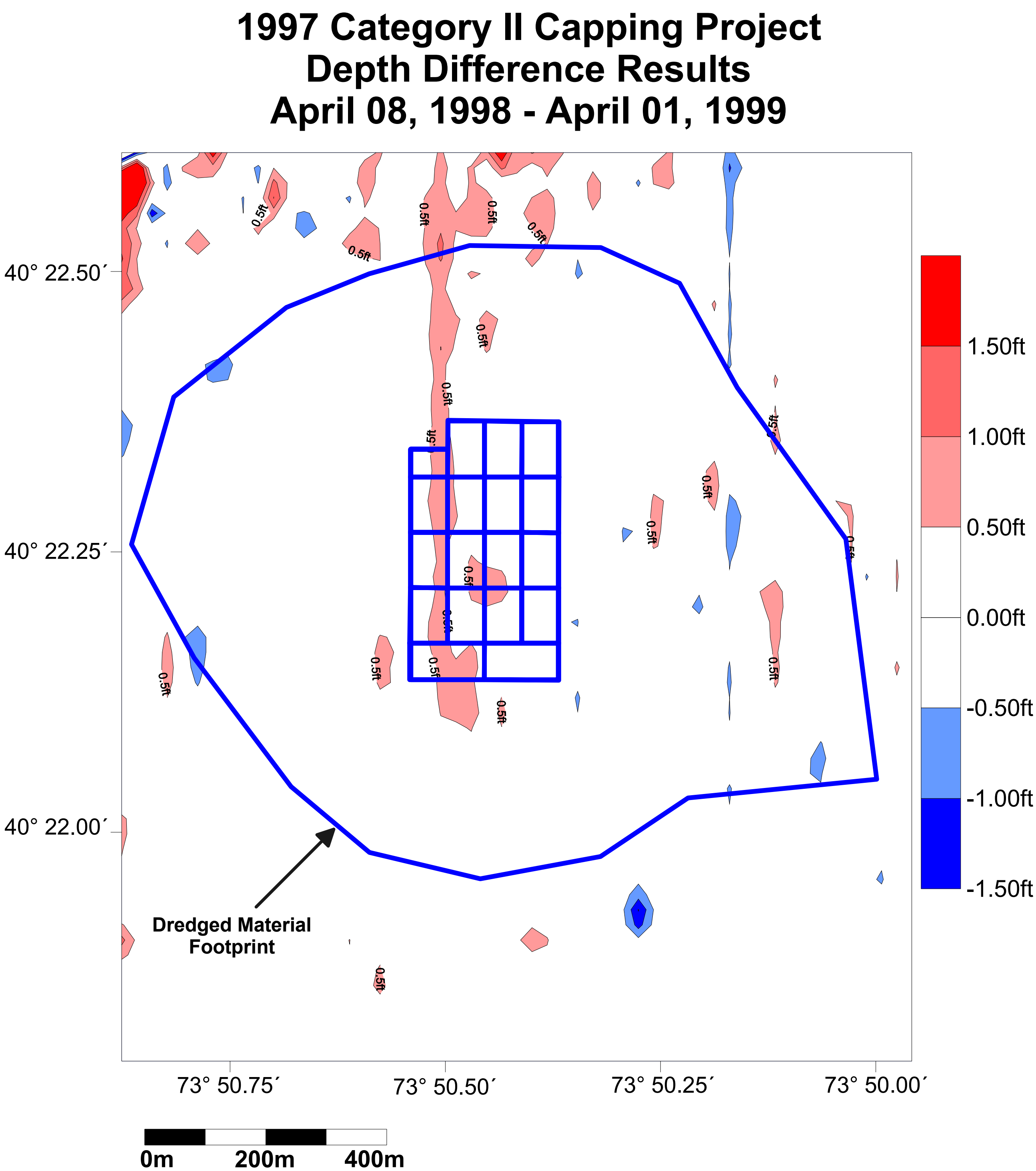


Figure 5.1-1. Two-dimensional contour plot showing the depth difference between the April 1998 postcap and April 1999 one-year postcap bathymetric surveys

are largely artifacts of the depth differencing procedure, consistent with the results of the previous survey (Figure 5.1-1). The overall lack of significant depth difference in Figure 4.1-3 provides one line of evidence that the thickness and overall morphology of the sand cap remained stable between the April 1999 and August 2002 surveys. No significant change in sand cap thickness has been detected by any bathymetric survey following the completion of the cap in January 1998.

Sub-bottom profiling is a second acoustic sampling technique used in the past and during the August 2002 survey to provide insights on cap thickness and long-term stability. The 2002 sub-bottom survey results indicated an average cap thickness of 5 to 7 feet (1.5 to 2.2 m). The greatest cap thickness occurred in the western portion of the 1997 Category II Mound, indicating overlap with the 1993 Dioxin Mound with 7 to 9 feet (2.2 to 2.7 m) of cap material (Figure 4.2-1). Another area in the center of the 1997 Category II Mound had an apparent cap thickness of up to 8 ft (2.4 m). The previous sub-bottom survey of November 1997 was conducted 2 months before the completion of the 1997 Category II Mound capping operation and did not cover the entire mound area; however, results from this survey did indicate that the entire mound was covered by at least 3 ft (~1 m) of sand, and a cap thickness of more than 6 ft (1.8 m) was detected over some portions of the mound.

It was not impossible to make any quantitative comparisons between the 2002 and 1997 surveys because of the timing of the 1997 survey, but both surveys did indicate significant ranges of cap thickness over the mound. In addition, there was also expected variability in the process of tracking and digitizing the sub-bottom reflectors in both data sets. This variability was seen between the 2002 and January 1994 sub-bottom profile results over the 1993 Dioxin Mound and was partially responsible for an apparent 1-2 ft increase in cap material thickness over that mound since 1994 (SAIC 2003b). Since the 2002 sub-bottom survey data were collected and processed simultaneously over the 1993 Dioxin and 1997 Category II Mounds, it is reasonable to assume the same reflector tracking and digitization variability exists in the 1997 Category II Mound sub-bottom data sets. Regardless, the 2002 sub-bottom survey results support the conclusion that the sand cap has remained as a stable feature over the surface of the 1997 Category II Mound.

The results of the 2002 vibracoring survey provide a third method of evaluating cap thickness and long-term stability. This method provides both an independent evaluation of cap thickness and a way to “ground truth” or verify the sub-bottom profiling and bathymetric depth differencing results. The 2002 cores showed an overall average cap thickness of approximately 174 cm (1.7 m or 5.7 ft). One 2002 survey core (97P) collected near the center of the 1997 Category II Mound did not penetrate through the sand cap and collected 264 cm (2.6 m or 8.7 ft) of cap material. Without a distinct cap/dredged material interface visible in this core, a determination of the actual cap thickness could not be made at this station. The previous 1999 coring survey indicated an overall average cap thickness of approximately 153 cm (1.5 m or 5.0 ft), suggesting an apparent increase of 20 cm (0.2 m or 0.5 ft) of cap material in the cores since the 1999 survey. The measured cap thickness at some stations was not appreciably different between the May 1999 and August 2002 surveys, while at other stations differences of as high as 1.1 m were observed (Table 4.6-1). Eight cores from the 2002 survey contained the same or more cap material than those from the same location from the previous survey, while six cores indicated an apparent loss of cap material. These results are attributed to small-scale spatial variability historically observed in the thickness of the cap over the 1997 Category II Mound, as reflected to some degree in the sub-bottom profiling results as well as in the results of previous coring surveys.

A comparison of the coring and sub-bottom profiling results is presented in Table 5.1-1. This table shows the cap thickness (in feet) measured in each core compared to the cap thickness determined at the nearest sub-bottom profiling point (i.e., a point from the actual survey trackline as opposed to the less-accurate gridded data from the contour map). The overall average cap thickness of 5.7 feet (1.7 m) measured from the cores is less than the sub-bottom profiling average of 7.0 feet (2.1 m; Table 5.1-1). Although there were several stations where sub-bottom profiling over-estimated and one station where it under-estimated the cap thickness by a few feet (up to 3.1 ft), these results are attributed both to the actual spatial variability in cap thickness across the mound and the lower resolution (estimated to be on the order of ±1 to 3 feet) of the acoustic sub-bottom profiling method. Both sets of results, however, support the conclusion that a uniform sand cap having an average thickness of at least 1.7 m has been maintained across the surface of the 1997 Category II Mound.

Finally, the REMOTS survey results provide another independent means of evaluating long-term sand cap stability. In the August 2002 survey, the spatial distribution of clean, rippled fine sand comprising the cap (Figure 4.4-1) did not differ from that found in the two previous postcap REMOTS surveys of the 1997 Category Capping Project Mound conducted in 1998 and 1999. Specifically, cap sand was consistently observed at the REMOTS stations located within the footprint of the sand cap as delimited in previous surveys. Consistent with past survey results, there were a few REMOTS stations on the sand cap where a layer of black, fine-grained sediment was observed underneath a surface layer of clean cap sand. The black sediment is assumed to represent a small, shallow patch of dredged material, possibly from nearby disposal operations or associated with the original placement of the capping sand. Based on the coring and sub-bottom profiling results showing average cap thickness of greater 1.7 m across the entire 1997 Category II Capping Project Mound, it is assumed that additional sand cap material underlies these shallow "puddles" of dredged material visible in the REMOTS images at the cap surface. In any future coring surveys of the 1997 Category II Capping Project Mound, it is recommended that cores be obtained at a few of the stations exhibiting this stratigraphy (e.g., Stations ENE0, ESE300, SSW200, NNW100, or WSW200) to verify the overall cap thickness at these locations.

5.2 Long-Term Effectiveness of Cap in Isolating Contaminants

All twelve of the cap material samples, collected in the six cores at intervals of 10 cm and 30 cm above the cap/dredged material interface, contained negligible levels of both dioxin and furan. Specifically, dioxin and furan concentrations in all of these samples were less than the analytical Level of Detection (LOD) of 1 pptr. Detectable levels of both dioxin and furan were found in the underlying dredged material in the cores, at levels ranging from 0.4 to 22 pptr. Overall, these results suggest that there has been no vertical migration of dioxin and furan from the underlying dredged material into the overlying cap material layer, as these contaminants were not detected in any of the cap material samples.

Table 5.1-1.
Cap Thickness Comparison between the 2002 Cores and Sub-bottom Data Points

Core Station ID	Total Core Length (ft)	2002 Cap Thickness (ft)	Distance of Sub-bottom Data Point to Core (ft)	Cap Thickness at nearest Sub-bottom Data Point (ft)	Difference between Core Cap Thickness and Sub-bottom Cap Thickness (ft)
97A	9.4	3.5	130	4.4	0.9
97B	9.7	3.2	120	6.3	3.1
97C	7.7	6.2	200	7.4	1.1
97D	9.3	6.8	0	8.8	2.0
97E	9.3	4.7	225	5.7	1.0
97L	9.2	8.5	40	10.4	1.9
97O	9.4	8.5	210	10.2	1.6
97P	8.7	>8.7	125	9.8	<1.2
97Q	9.6	3.0	0	5.1	2.1
97R	9.6	5.0	110	5.0	0.0
97S	9.2	7.3	40	8.7	1.4
97T	9.6	4.3	40	5.1	0.8
97U	9.3	3.7	160	5.4	1.6
97V	9.5	6.7	150	5.5	-1.1
Average	**9.2**	**5.7**	**111**	**7.0**	**1.3**

The dioxin and furan results from the August 2002 survey are consistent with those of the two previous postcap coring surveys (May 1998 and 1999) over the 1997 Category II Capping Project Mound (Figures 5.2-1 and 5.2-2). In every survey, the measured concentrations of dioxin and furan in the cap material have been negligible, with the overall averages consistently below the required detection limit of 1 pptr (Figure 5.2-1). In general, the critical period for potential contamination of cap sediments is during the early stages of a capping project, when consolidation may cause pore water to move up (advect) from the contaminated dredged material into the overlying cap layers. However, the results of the postcap coring surveys demonstrate that this process, if it was occurring, has not resulted in any measurable increase in contaminants in the cap over the 1997 Category II Mound (Figure 5.2-1). The 2002 results support the conclusion that the cap continues to remain effective in isolating the dioxin and furan in the underlying dredged material.

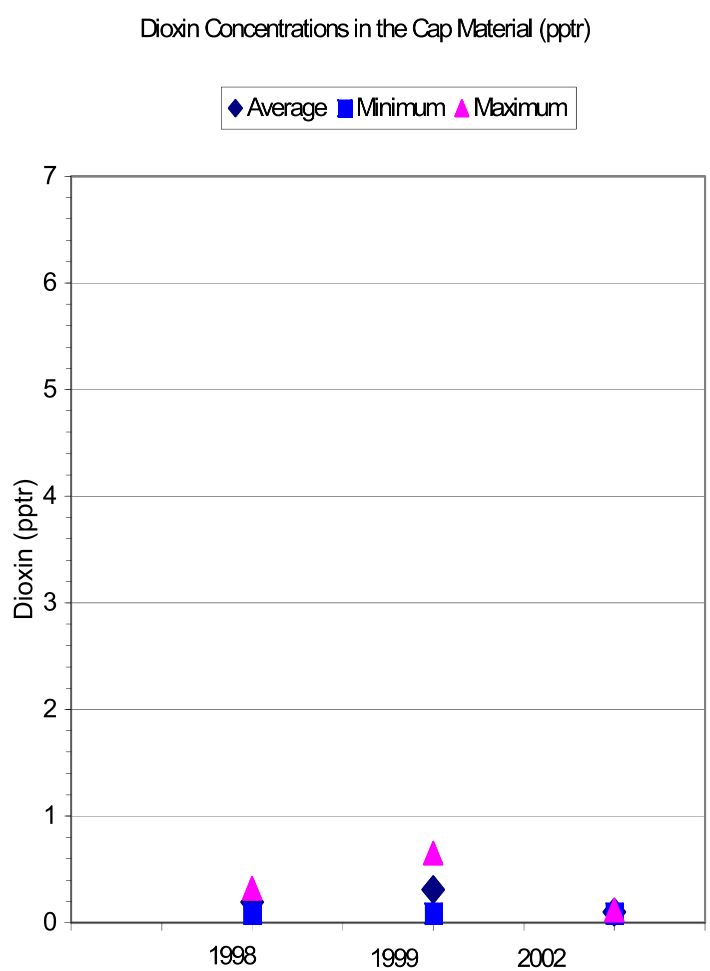
The average dioxin and furan concentrations measured in the underlying, fine-grained dredged material have consistently been elevated relative to the overlying cap material (Figure 5.2-2). Based on the standard deviations and minimum/maximum values shown in Figure 5.2-2, the measured dioxin and furan concentrations in the dredged material have been variable, both within and among surveys. These elevated concentrations are not unexpected, given the pre-dredging characterization of these sediments as Category II dredged material requiring capping.

5.3 Benthic Recolonization Status of the Capped Mound

In past REMOTS surveys over the 1997 Category II Mound, it was found that the rippled well-sorted fine sand comprising the cap had been recolonized by a benthic community consisting of tube-dwelling, small-bodied polychaetes inhabiting the sediment surface (i.e., pioneering Stage I organisms). A similar Stage I benthic community also has been found in the past to be dominant at the South Reference Area. The 2002 REMOTS survey results are in good agreement with these previous results; Stage I was the dominant successional stage at both the 1997 Category II Mound and reference area stations.

The consistency of these results over many years of monitoring support the conclusion that infaunal succession beyond Stage I is not likely to occur on the sand cap or in the South Reference Area. The ripples observed in both areas suggest that the sand experiences periodic bedload transport, most likely from elevated bottom currents or wave action during the passage of large storms. The physical instability of the sand surface favors the long-term dominance of surface-dwelling, opportunistic organisms. In addition, larger-bodied, Stage III deposit-feeders require soft, organic-rich sediments; Stage III communities have difficulty becoming established on clean, rippled sand bottoms but were found in a few isolated areas with finer-grained surface sediment. For example, many of the stations surrounding the 1997 Category II Mound, where fine-grained, organic-rich dredged material is present, displayed a mixed community of both surface-dwellers (Stage I) and sub-surface deposit-feeders (Stage III), similar to communities found in the past at these stations.

At several of the 2002 stations located over the 1997 Category II Mound sand cap, the REMOTS images revealed stick-dwelling or stalked amphipods of the Family Podoceridae at the sediment surface (e.g., Figure 4.4-14). There is a strong probability that these amphipods are *Dulichia porrecta*, as this Podocerid species was found in the benthic grab samples collected at selected



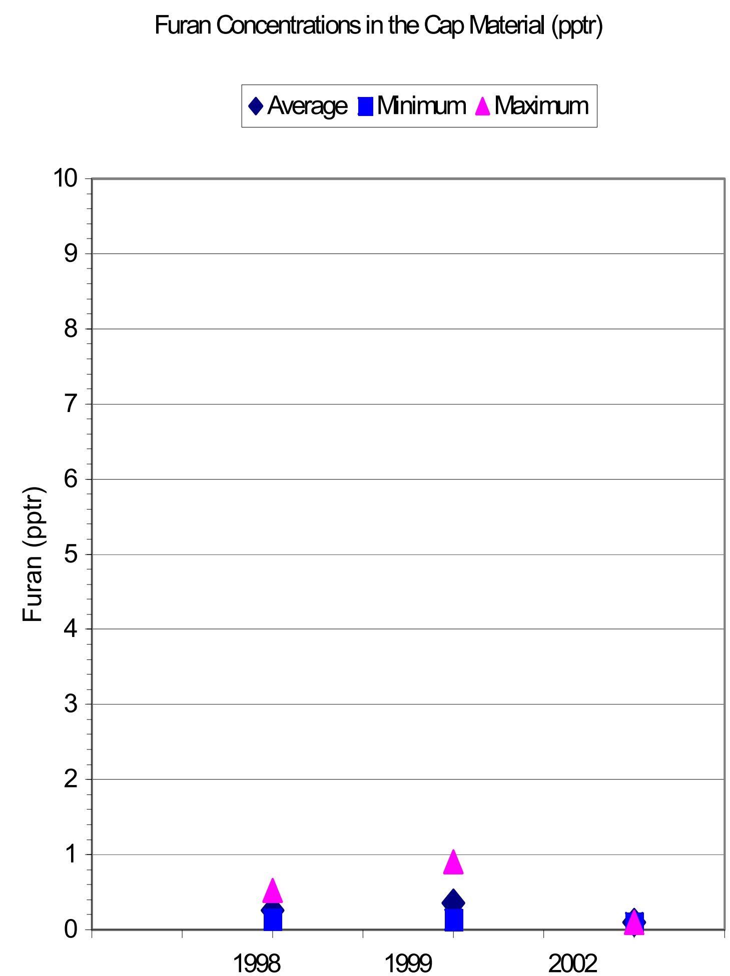


Figure 5.2-1. Average dioxin and furan concentrations in the cap material at the1997 Category II Mound for coring surveys conducted in May 1998, May 1999, and August 2002

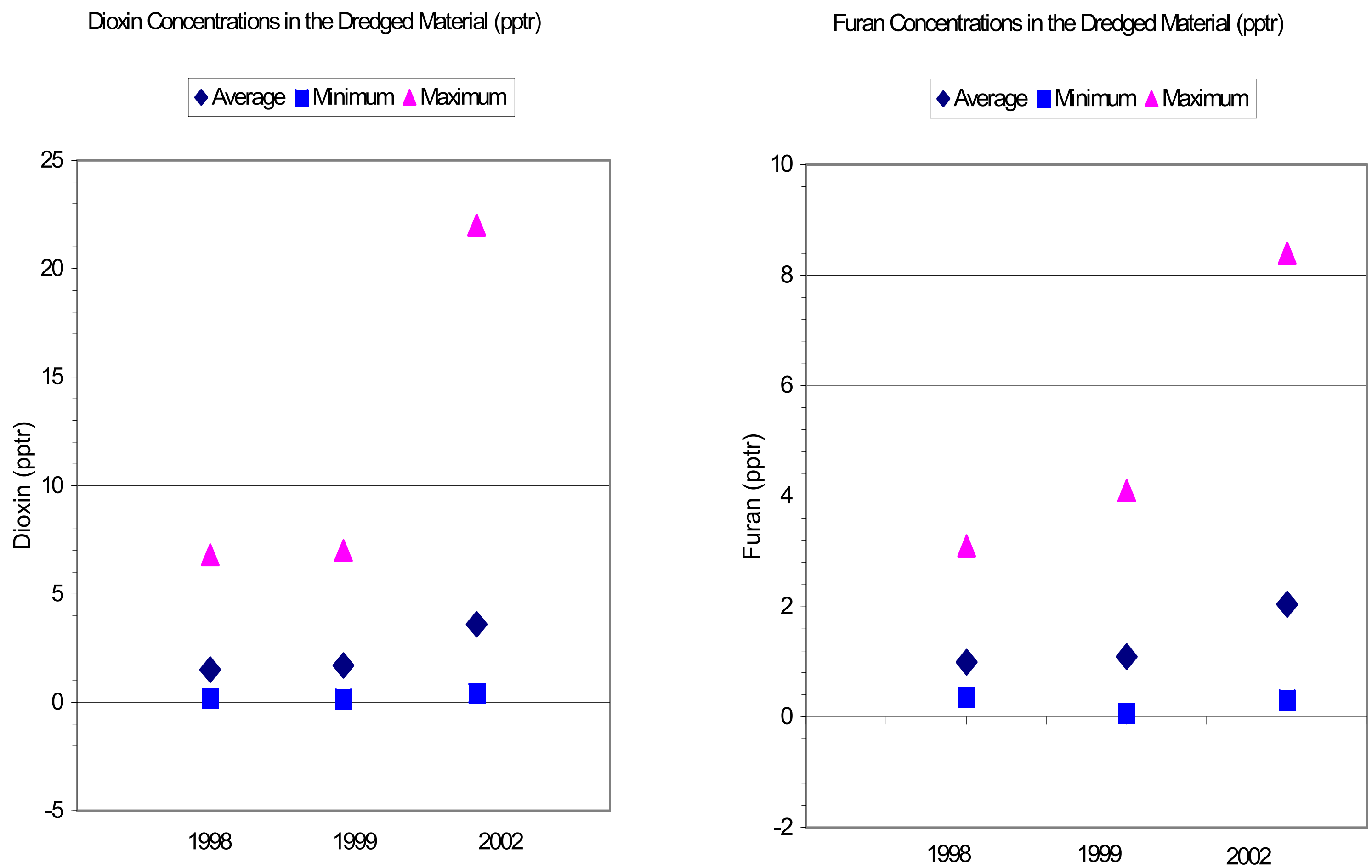


Figure 5.2-2. Average dioxin and furan concentrations in the dredged material at the 1997 Category II Mound for coring surveys conducted in May 1998, May 1999, and August 2002

REMOTS stations over the 1997 Category II Mound sand cap. The amphipod stalks appear to be delicate structures that are probably not able to withstand elevated bottom currents or sand movement. Their presence on the 1997 Category II Mound during the summer 2002 REMOTS survey suggests that the mound surface had probably not experienced significant sand movement or elevated bottom currents for at least several weeks or months preceding the survey. Given the likelihood that the delicate stalks would be removed during higher-energy storm events, the stick-dwelling amphipod *Dulichia porrecta* may only be an ephemeral member of the Stage I/II community inhabiting the surface of the sand cap.

The taxonomic data from the benthic grabs provides a means of "ground-truthing" the REMOTS image interpretation. In general, many of the taxa that were most abundant in the 2002 survey of the 1997 Category II Capping Project Mound South Reference Area have historically been found among the dominants in other studies of benthic assemblages in the New York Bight (Vittor and Associates 1996; Carracciolo and Steimle 1983; Chang et al. 1992). The numerically dominant taxa at both the 1997 Category II Mound and South Reference Area stations included several Stage I polychaetes and/or the Stage II bivalve *Nucula proxima*. These results agree with the REMOTS data showing a dominance of Stage I and some Stage II over the surface of the capped mound (Figure 4.4-22). Furthermore, the taxonomic data indicated a mixture of successional stages at the 1997 Off-Mound stations, including Stage I polychaetes, high numbers of the Stage II bivalve *Nucula proxima*, and a significant number of Stage III polychaetes (e.g., *Nephtys incisa*, *Levinsenia gracilis*, and *Scoletoma verrilli*) among the dominants. These results are also in good agreement with the REMOTS interpretation, which indicated that the Off-Mound stations having relic, fine-grained dredged material were characterized by predominantly Stage I on III successional stages.

The benthic community at the 1997 Category II Mound stations was dominated by many of the same taxa that were dominant at the South Reference Area stations, but there were significant differences between the two areas in the relative abundances of these taxa. Despite these differences in community structure, the two areas had, on average, comparable organism density, diversity, richness and evenness. It is possible to conclude that the surface of the 1997 Category II Capping Project Mound was supporting a relatively abundant and diverse benthic community at the time of the summer 2002 survey. This community was mainly comprised of surface-dwelling, Stage I and II taxa that are adapted to maintaining populations despite periodic physical disturbance. A predominantly Stage I community also was found at the South Reference Area, but the overall structure of this community was different from that at the 1997 Category II Mound stations.

Reflecting the widespread presence of Stage I organisms and relatively well-developed aRPD depths, average OSI values of greater than +6 were calculated for both the capped mound and reference area stations. Such values are considered indicative of non-degraded benthic habitat quality in both areas at the time of the 2002 survey.

The 1997 Off-Mound stations had a benthic community that was very dissimilar to the communities found at the 1997 Category II Mound stations and South Reference Area stations. This is attributed to the significant difference in the composition of the sediment at the 1997 Off-Mound stations compared to the other two areas. Organic-rich, fine-grained relic dredged material characterized the 1997 Off-Mound stations, compared to the fine and medium sands that dominated at the 1997 Category II Mound and South Reference Area stations. This fine-grained sediment was supporting very high number of *Nucula proxima*, and the dominance of this single species accounted for much of the difference in community structure between the 1997 Off-Mound versus the 1997 Category II Mound and South Reference Area stations. In the New York Bight, *Nucula proxima* prefers fine silty sediments with relatively high organic content (Caracciolo and Steimle 1983). Likewise, several Stage III polychaetes that were relatively abundant at the 1997 Off-Mound stations were not found at the 1997 Category II Mound and South Reference Area stations. Due to the dominance of *Nucula proxima*, the 1997 Off-Mound stations had comparatively low species diversity, evenness and richness compared to the other two areas (Table 4.5-5).

6.0 CONCLUSIONS

- The results of the precision bathymetric survey conducted over the 1997 Category II Mound during summer 2002 were compared to the results of the previous bathymetric survey of April 1999. An overall depth difference was noted of 1.2 ft, however, this was determined to be a survey artifact in the 1999 dataset. After a correction factor of –1 ft was applied to the 1999 survey data, no significant change was noted between surveys.

- The lack of depth change between the two successive bathymetric surveys suggests no appreciable change in the distribution or thickness of the sand cap since its creation in 1998.

- The summer 2002 sub-bottom profiling results were consistent with the bathymetric depth differencing results, indicating an average sand cap thickness of 5 to 7 feet, with the greatest thickness (up to 9 feet) observed in the area of overlap between the 1993 Dioxin and 1997 Category II Mounds.

- Sediment cores obtained in August 2002 revealed an average cap thickness of 1.7 m (5.7 ft) over the 1997 Category II Mound. Cap thickness was variable among cores, ranging from 90 cm to greater than 264 cm. These results are consistent with previous postcap coring surveys and reflect small-scale spatial variability in cap thickness. Cap thickness measurements from the cores were generally comparable to the cap thickness estimates obtained through sub-bottom profiling.

- The spatial distribution of cap sand detected at the 2002 REMOTS sediment-profile imaging stations was similar to that observed in two previous postcap REMOTS surveys over the 1997 Category II Mound. Overall, the combined results of the summer 2002 bathymetric, sub-bottom profiling, coring and REMOTS surveys support the conclusion that the sand cap has remained stable since its creation in 1998.

- Negligible concentrations of dioxin and furan (i.e., less than the 1 part per trillion level of detection) were measured in the cap material. Detectable levels of dioxin and furan in the underlying dredged material ranged from less than 1 to 22 parts per trillion. These results are consistent with those of previous postcap coring surveys and indicate a lack of any significant vertical migration of dioxin or furan from the underlying dredged material into the overlying cap material. These results support the conclusion that the cap continues to remain effective in isolating the dioxin and furan.

- The 2002 REMOTS results indicated that the surface of the sand cap continued to be inhabited by a benthic community comprised of small, surface-dwelling opportunists (Stages I and II), similar to the community at the nearby South Reference Area. In the area of the HARS surrounding the sand cap, where fine-grained historic dredged material occurs, the benthic community consisted of a mixture of surface-dwellers (Stage I) and deeper-dwelling deposit-feeders (Stage III).

- Benthic grab samples showed that the numerically dominant taxa at both the 1997 Category II Mound and the South Reference Area included several Stage I polychaetes and Stage II amphipods. The Stage II bivalve *Nucula proxima* was found in relatively high numbers at the stations with fine-grained relic dredged material in the area surrounding the capped mound. The benthic grab sampling results were generally consistent with the REMOTS results in showing that the 1997 Category II Mound and South Reference Area were both inhabited by relatively abundant and diverse benthic communities at the time of the summer 2002 surveys. Among-station differences in the composition of these communities were attributed to differences in sediment grain size.

- Both the REMOTS and benthic grab sampling results indicate that the surface of the 1997 Category II Mound represented a relatively healthy and productive habitat for benthic organisms at the time of the summer 2002 survey.

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Appendix A
REMOTS Image Analysis Results

Appendix A-1

REMOTS Sediment- Profile Imaging Data from the 1997 Dioxin Mound Capping Project Area, June 2002 Survey

Station	Replicate	Date	Time	Successional	Grain Size (phi)			Benthic	Mud Clasts		Camera Penetration (cm)				Dredged Material Thickness (cm)			Cap Material Thickness (cm)	Redox Rebound Thickness (cm)			Apparent RPD Thickness (cm)			Methane			OSI	Surface	Low	Comments
				Stage	Min	Max	Maj Mode	Habitat	Count	Avg. Diam	Min	Max	Range	Mean	Min	Max	Mean	Mean	Min	Max	Mean	Min	Max	Mean	Count	Mean	Diam.		Roughness	DO	
E0	B	6/19/2002	14:45	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.02	3.75	1.73	2.88	0	0	0	>2.88	0	0	0	>2.02	>3.75	>2.88	0	0	0	5	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell frags-far
E0	C	6/19/2002	14:45	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	1	0.25	2.3	6.25	3.95	4.28	0	0	0	>4.28	0	0	0	>2.30	>6.25	>4.28	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, shell bits, sand ripple, lg burrowing worms @z, red clast
E100	B	6/19/2002	14:54	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.7	3.73	1.03	3.22	0	0	0	>3.22	0	0	0	>2.7	>3.73	>3.22	0	0	0	6	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand dollars-far, shell frags, stick amp-far?
E100	C	6/19/2002	14:55	ST I to II	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.32	6.11	3.79	4.22	0	0	0	>4.22	0	0	0	>2.32	>6.11	>4.22	0	0	0	8	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand ripple, stick amp-far, shell bits, sm burrow opening?
E200	A	6/19/2002	14:59	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.84	6.43	1.59	5.64	0	0	0	>5.64	0	0	0	>4.84	>6.43	>5.64	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, tubes-far, shell frag @ surf, sand ripple
E200	B	6/19/2002	14:59	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.68	7.8	4.12	5.74	0	0	0	>5.74	0	0	0	>3.68	>7.80	>5.74	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, tubes-far, fecal casts-far
E300	A	6/19/2002	15:13	ST II	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.32	5.46	1.14	4.89	0	0	0	>4.89	0	0	0	>4.32	>5.46	>4.89	0	0	0	9	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, tubes, stick amp, shell bits, sanddollar-far?, sand ripple-far
E300	B	6/19/2002	15:14	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.59	5.41	1.82	4.5	0	0	0	>4.50	0	0	0	>3.59	>5.41	>4.5	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
E400	D	6/21/2002	12:34	ST I	3 to 2 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	4.45	8.02	3.57	6.24	0	0	0	>6.24	0	0	0	1.96	6.17	5.07	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, tubes, stick amp-far?, sand ripple, shell bits
E400	F	6/21/2002	12:35	ST I	3 to 2 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	3.88	6.02	2.14	4.95	0	0	0	>4.95	0	0	0	>3.88	>6.02	>4.95	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, fecal cast-far, shell bits, sm tubes?
E500	D	6/21/2002	12:42	ST I	4 to 3 phi	1 to 0 phi	2 to 1 phi	SA.M	0	0	4	4.48	0.48	4.24	0	0	0	>4.24	0	0	0	>4.00	>4.48	>4.24	0	0	0	7	Physical	NO	Brn cap sand material >pen, thin flocculent layer @ surf?, RPD >pen, tubes, org @ surf, sand ripple-far
E500	F	6/21/2002	12:43	ST I	4 to 3 phi	1 to 0 phi	2 to 1 phi	SA.M	0	0	5.95	6.54	0.59	6.24	0	0	0	>6.24	0	0	0	-99.00	-99.00	-99.00	0	0	0	99	Physical	NO	Brn sand cap material >pen, shell bits, sm tubes
E600	D	6/21/2002	12:49	ST I	4 to 3 phi	2 to 1 phi	4 to 3 phi	SA.F	0	0	2.71	4.11	1.4	3.41	0	0	0	0.00	0	0	0	>2.71	>4.11	>3.41	0	0	0	6	Physical	NO	Uniform tan ambient sand>pen, red sed patch@z, tubes,shell frags, sand ripples-far,biogenic mound?
E600	F	6/21/2002	12:50	ST I to II	> 4 phi	3 to 2 phi	> 4 phi	UN.SS	3	0.31	5.38	5.82	0.44	5.6	> 5.38	> 5.82	> 5.6	0.00	0	0	0	1.47	5.12	2.65	0	0	0	6	Biogenic	NO	Muddy fine-grained relic dm>pen, worms @z, tubes, Amp tubes?; surf rework, ox&red clasts
E700	A	6/19/2002	15:38	ST I to II	> 4 phi	4 to 3 phi	> 4 phi	UN.SF	0	0	14.86	16.04	1.18	15.45	> 14.86	> 16.04	> 15.45	0.00	0	0	0	0.84	5.19	3.36	0	0	0	7	Biogenic	NO	Relic DM >pen, tan muddy sand/blk m,tubes, fecal mounds, surf rework, worms@z, Nucula?
E700	D	6/21/2002	12:55	ST I to II	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	3	0.25	9.75	10.23	0.48	9.99	> 9.75	> 10.23	> 9.99	0.00	0	0	0	0.14	3.79	2.44	0	0	0	6	Physical	NO	Relic dm >pen, tan muddy fine sand/blk sulfidic m, tubes, Nucula, fecal mound or wiper clast, developing artifact, ox & red clasts, stick amp-far?, worms @z?
E800	G	6/24/2002	10:48	ST II on III	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	0	0	10.43	10.7	0.27	10.57	> 10.43	> 10.7	> 10.57	0.00	0	0	0	1.82	5.89	3.26	0	0	0	10	Biogenic	NO	Relic DM>pen, tan muddy fine sand/blk sulfidic m, tubes, stick amps, void, surf reworking, fluid clast lyr?, burrow opening
E800	H	6/24/2002	10:48	ST I to II	> 4 phi	3 to 2 phi	> 4 phi	UN.SI	8	0.72	8.79	9.55	0.76	9.17	> 8.79	> 9.55	> 9.17	0.00	0	0	0	0.07	3.91	0.82	0	0	0	4	Physical	NO	Relic DM>pen, tan muddy sand mixed w/ blk sulfidic m, red clasts, tubes, stick amps-far, patchy RPD
ENE0	B	6/21/2002	12:19	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.04	4.59	1.55	3.82	0	0	0	2.80	0	0	0	1.21	3.41	2.00	0	0	0	4	Physical	NO	Brn sand cap material over black muddy relic dm, sand ripple, starfish-far, shell bits, tubes-far, red sed @z
ENE0	C	6/21/2002	12:19	ST I	4 to 3 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	4.71	5.66	0.95	5.18	0	0	0	>5.18	0	0	0	>4.71	>5.66	>5.18	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, shell bits
ENE100	A	6/21/2002	12:12	ST II	> 4 phi	3 to 2 phi	> 4 phi	UN.SI	1	0.32	7.5	7.82	0.32	7.66	> 7.5	> 7.82	> 7.66	0.00	0	0	0	0.63	4.63	2.76	0	0	0	7	Biogenic	NO	Relic DM>pen, tan/blk muddy silt, shell bits, tubes, stick amps, red clast, fecal mound, sm worm @z
ENE100	B	6/21/2002	12:13	ST II	> 4 phi	3 to 2 phi	> 4 phi	UN.SI	0	0	7.27	8.07	0.8	7.67	> 7.27	> 8.07	> 7.67	0.00	0	0	0	1.35	4.91	2.54	0	0	0	7	Physical	NO	Relic DM>pen, tan/blk muddy silt, tubes, stick amp?, shell bits, biogenic mound; Nucula
ENE200	A	6/21/2002	12:06	ST II on III	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	0	0	16.91	17.48	0.57	17.19	> 16.91	> 17.48	> 17.19	0.00	0	0	0	0.43	5.26	2.17	0	0	0	8	Biogenic	NO	Relic DM>pen, tan/blk mud, poly tubes, stick amps, void, Nucula, shell bits, surf reworking, burrow opening, red sed @surf
ENE200	C	6/21/2002	12:07	ST II to III	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	3	0.32	16.41	16.5	0.09	16.45	> 16.41	> 16.5	> 16.45	0.00	0	0	0	0.07	4.05	1.30	0	0	0	6	Physical	NO	Relic DM>pen, tan mud over black sulfidic mud, red clasts, patchy RPD, lg burrowing worm=Nephtys, Nucula, shell bits, fecal/flock layer
ENE300	A	6/21/2002	11:56	ST II to III	> 4 phi	3 to 2 phi	> 4 phi	UN.SI	2	0.46	16.57	17.46	0.89	17.01	> 16.57	> 17.46	> 17.01	0.00	0	0	0	0.84	5.68	3.98	0	0	0	10	Biogenic	NO	Relic DM>pen, tan muddy fine sand/blk m, stick amps, Nucula, shell bits, surf reworking, ox clasts, sm void?, burrow, biogenic mound?, sm worm @z
ENE300	B	6/21/2002	11:57	ST II	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	12	0.5	17.32	17.93	0.61	17.62	> 17.32	> 17.93	> 17.62	0.00	0	0	0	0.07	5.26	1.11	0	0	0	5	Physical	NO	Relic DM>pen, tan muddy fine sand/blk m, stick amps, ox & red clasts, worm @z, shell bits, patchy RPD, Nucula
ESE0	D	6/21/2002	13:31	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.48	5.2	1.72	4.34	0	0	0	>4.34	0	0	0	>3.48	>5.2	>4.34	0	0	0	7	Physical	NO	Uniform tan sand cap lyr>pen, tubes, sand ripple, RPD >pen
ESE0	F	6/21/2002	13:34	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.61	4.43	0.82	4.02	0	0	0	>4.02	0	0	0	>3.61	>4.43	>4.02	0	0	0	7	Physical	NO	Tan sand cap >pen, shell frags, tubes-far
ESE100	E	6/21/2002	13:41	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	5.66	6.16	0.5	5.91	0	0	0	>5.91	0	0	0	>5.66	>6.16	>5.91	0	0	0	7	Physical	NO	Homogenous tan sand cap >pen, shell frags, RPD >pen
ESE100	F	6/21/2002	13:41	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.66	4.7	1.04	4.18	0	0	0	>4.18	0	0	0	>3.66	>4.70	>4.18	0	0	0	7	Physical	NO	Uniform tan sand cap >pen, RPD>pen?, fecal casts-far, tubes?
ESE200	A	6/19/2002	16:10	ST II	> 4 phi	3 to 2 phi	4 to 3 phi	UN.SS	0	0	9.05	9.45	0.4	9.25	0	0	4.64	4.29	0	0	0	0.91	5.12	2.29	0	0	0	7	Biogenic	NO	Sand cap lyr over relic dm, tan sand/blk sandy m, stick amps, tubes, shell bits, surf rework, fecal/flock lyr
ESE200	D	6/21/2002	13:51	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.25	5.38	1.13	4.82	0	0	0	>4.82	0	0	0	>4.25	>5.38	>4.82	0	0	0	7	Physical	NO	Homogenous tan sand cap lyr >pen, sand ripple, tubes, RPD>pen
ESE300	G	6/24/2002	10:41	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.2	4.41	1.21	3.8	0	0	0	>3.80	0	0	0	>3.20	>4.41	>3.80	0	0	0	7	Physical	NO	Homogenous sand cap>pen, RPD >pen, tubes, fecal casts-far?
ESE300	H	6/24/2002	10:42	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.86	4.64	0.78	4.25	0	0	0	>4.25	0	0	0	3.34	4.55	3.25	0	0	0	6	Physical	NO	Homogenous tan sand cap >pen, RPD >pen?, tubes?, burrow opening
ESE400	A	6/20/2002	09:34	ST II	>4 phi	2 to 1 phi	4 to 3 phi	UN.SS	0	0	6.29	7	0.71	6.64	> 6.29	> 7	> 6.64	0.00	0	0	0	1.00	3.41	1.94	0	0	0	6	Biogenic	NO	Sandy relic dm>pen, brn sand/blk silty sand, dense surf tubes, stick amps (Podocerids), Nucula? shell bits
ESE400	C	6/20/2002	09:35	ST II	>4 phi	3 to 2 phi	4 to 3 phi	UN.SS	0	0	4.66	5.07	0.41	4.86	> 4.66	> 5.07	> 4.86	0.00	0	0	0	0.28	4.69	2.35	0	0	0	7	Biogenic	NO	Sandy relic dm>pen, Brn fine sand/blk silty sand, dense surf tubes, ampelsica and stick amps, shell bits
ESE500	B	6/20/2002	09:43	ST I	>4 phi	< -1 phi	4 to 3 phi	HR	0	0	3.61	7.95	4.34	5.78	> 3.61	> 7.95	> 5.78	0.00	0	0	0	1.99	5.62	2.81	0	0	0	5	Physical	NO	No visible cap material, Relic DM >pen, rock, brick & cobble/brn muddy fine sand, shell frags
ESE500	C	6/20/2002	09:43	INDET	4 to 3 phi	< -1 phi	4 to 3 phi	HR	0	0	1.54	4.25	2.71	2.89	> 1.54	> 4.25	> 2.89	0.00	0	0	0	-99.00	-99.00	-99.00	0	0	0	99	Physical	NO	Relic DM>pen, rock & cobble/brn muddy fine sand, brick frags, shell frags, dist surf, bryozoans
N0	A	6/21/2002	09:59	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.55	4.48	0.93	4.01	0	0	0	>4.01	0	0	0	>3.55	>4.48	>4.01	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, shell bits, sand ripple
N0	B	6/21/2002	09:59	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.73	4.04	1.31	3.38	0	0	0	>3.38	0	0	0	>2.73	>4.04	>3.38	0	0	0	6	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, shell bits, sand ripple
N100	A	6/21/2002	10:04	ST I	3 to 2 phi	1 to 0 phi	2 to 1 phi	SA.M	0	0	3.21	4.32	1.11	3.77	0	0	0	>3.77	0	0	0	>3.21	>4.32	>3.77	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand ripple, tubes-far, fecal casts-far
N100	B	6/21/2002	10:05	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.34	6.91	3.57	5.12	0	0	0	>5.12	0	0	0	>3.34	>6.91	>5.12	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand ripple, tubes
N200	A	6/21/2002	10:09	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	1	0.42	4.16	6.23	2.07	5.19	0	0	0	>5.19	0	0	0	>4.16	>6.23	>5.19	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, ox clast, shell bits
N200	B	6/21/2002	10:10	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.41	5.55	3.14	3.98	0	0	0	>3.98	0	0	0	>2.41	>5.55	>3.98	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, shell bits, fecal casts-far, sand ripple?
N300	A	6/21/2002	10:14	ST I	> 4 phi	3 to 2 phi	> 4 phi	UN.SI	6	0.19	10.5	10.93	0.43	10.72	> 10.5	> 10.93	> 10.72	0.00	0	0	0	3.08	3.93	3.52	0	0	0	6	Physical	NO	Relic muddy DM >pen, sm tubes, ox clasts, surf reworking, shell bits, biogenic rewrking@surf
N300	B	6/21/2002	10:15	ST I	> 4 phi	3 to 2 phi	> 4 phi	UN.SI	4	0.21	10.84	11.25	0.41	11.05	> 10.84	> 11.25	> 11.05	0.00	0	0	0	0.07	4.20	1.86	0	0	0	4	Biogenic	NO	Relic DM >pen, tan muddy fine sand/blk sulfidic m, ox clasts, tube, shell bits, surf reworking, burrows, fecal/flock layer, patchy RPD
N400	D	6/24/2002	11:06	ST I	4 to 3 phi	< -1 phi	3 to 2 phi	SA.F	0	0	4.62	5.59	0.97	5.11	> 4.62	> 5.59	> 5.11	0.00	0	0	0	0.84	3.79	3.09	0	0	0	6	Physical	NO	Relic DM >pen, Brn fine sand/blk muddy fine sand, rock & pebbles @ surf, hydroids, bryozoans, shell bits, sm burrow
N400	E	6/24/2002	11:06	ST I	> 4 phi	< -1 phi	> 4 phi	UN.SI	0	0	5.07	5.96	0.89	5.52	> 5.07	> 5.96	> 5.52	0.00	0	0	0	1.00	3.41	1.43	0	0	0	3	Physical	NO	Relic DM >pen, Brn medium sand/blk sulfidic m, rocks @ surf, bryozoans,shell bits
N500	B	6/21/2002	10:36	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	10.48	10.93	0.45	10.7	0	0	0	0.00	0	0	0	4.84	5.75	5.29	0	0	0	7	Physical	NO	Ambient tan fine sand, deep RPD, sand ripple, shell frags, sm tubes
N500	C	6/21/2002	10:36	ST I	> 4 phi	2 to 1 phi	3 to 2 phi	UN.SS	0	0	6.34	7.79	1.45	7.07	0	0	2.77	0.00	0	0	0	3.34	5.41	3.23	0	0	0	6	Physical	NO	Tan ambient sand over fine-grained blk relic dm (outside sand cap footprint), sand ripple, shell bits, sm tubes
NE0	A	6/21/2002	11:11	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.54	4.89	1.35	4.22	0	0	0	>4.22	0	0	0	>3.54	>4.89	>4.22	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, tubes
NE0	B	6/21/2002	11:11	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.66	4.38	1.72	3.52	0	0	0	>3.52	0	0	0	>2.66	>4.38	>3.52	0	0	0	6	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell bits
NE100	B	6/21/2002	11:17	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.3	7.38	3.08	5.84	0	0	0	>5.84	0	0	0	>4.3	>7.38	>5.84	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, sm tubes-far
NE100	C	6/21/2002	11:17	ST I	3 to 2 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	4.59	6.71	2.12	5.65	0	0	0	>5.65	0	0	0	>4.59	>6.71	5.65	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, org floc@surf, sm tubes,shell frags,sand ripple
NE200	A	6/21/2002	11:21	ST I to II	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.36	7.45	3.09	5.9	0	0	0	>5.90	0	0	0	>4.36	>7.45	>5.9	0	0	0	7	Physical	NO	Brn/blk sand cap material >pen,shell bits, sand ripple, tubes,stick amps, red sed@z, RPD>pen
NE200	C	6/21/2002	11:22	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.05	7.21	4.16	5.13	0	0	0	>5.13	0	0	0	>3.05	>7.21	>5.13	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand ripple, shell bits, sm tubes
NE300	A	6/21/2002	11:25	ST I	3 to 2 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	4.7	4.93	0.23	4.81	0	0	0	>4.81	0	0	0	1.89	3.93	3.17	0	0	0	6	Physical	NO	Brn & blk sand cap material >pen, red sed patches @z, shell bits
NE300	B	6/21/2002	11:26	INDET	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	1.88	3	1.12	2.44	0	0	0	0.00	0	0	0	>1.88	>3	>2.44	0	0	0	99	Physical	NO	Brn ambient muddy fine sand >pen, underpen, RPD >pen, shell frags, burrow opening?
NE400	B	6/21/2002	11:33	ST I	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	0	0	15.93	16.77	0.84	16.35	> 15.93	> 16.77	> 16.35	0.00	0	0	0	0.07	0.77	0.52	0	0	0	2	Physical	NO	Relic soft muddy DM >pen, tan&blk sulfidic m, thin & patchy RPD, shell frags, worms @z, low DO?, fecal/flock layer, tubes, surf reworking
NE400	C	6/21/2002	11:34	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SF	2	0.52	14.64	15	0.36	14.82	> 14.64	> 15	> 14.82	0.00	0	0	0	0.07	2.06	0.50	0	0	0	-2	Physical	YES	Relic soft muddy DM>pen, tan/blk sulfidic sandy m, shell bits, thin & patchy RPD, redsed@surf=low DO, ox clasts, fecal/flock layer, Nucula?
NE500	A	6/21/2002	11:48	ST I to II	> 4 phi	4 to 3 phi	> 4 phi	UN.SF	0	0	16.89	17.64	0.75	17.26	> 16.89	> 17.64	> 17.26	0.00	0	0	0	0.21	2.85	0.80	0	0	0	0	Biogenic	YES	Relic sft muddy DM>pen,sulfidic m, tubes,m clumps/bio mounds?, Nucula?,shell bits,lg worm@z=Nepthys,thin&patchy RPD,fecal/flock lyr,surf rework,burrow open
NE500	B	6/21/2002	11:48	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SF	0	0	16.27	16.75	0.48	16.51	> 16.27	> 16.75	> 16.51	0.00	0	0	0	0.07	3.27	0.67	0	0	0	-2	Physical	YES	Relic soft muddy DM>pen, blk sulfidic m, patchy RPD, redsed@surf=low DO, shell bits, tubes, fecal layer, Nucula?

Appendix A-1 (continued)

REMOTS Sediment- Profile Imaging Data from the 1997 Dioxin Mound Capping Project Area, June 2002 Survey

Station	Replicate	Date	Time	Successional Stage	Grain Size (phi)			Benthic Habitat	Mud Clasts		Camera Penetration (cm)				Dredged Material Thickness (cm)			Cap Material Thickness (cm)	Redox Rebound Thickness (cm)			Apparent RPD Thickness (cm)			Methane			OSI	Surface Roughness	Low DO	Comments
					Min	Max	Maj Mode		Count	Avg. Diam	Min	Max	Range	Mean	Min	Max	Mean	Mean	Min	Max	Mean	Min	Max	Mean	Count	Mean	Diam.				
NNE0	B	6/21/2002	11:06	ST II	3 to 2 phi	1 to 0 phi	2 to 1 phi	SA.M	0	0	4.41	4.91	0.5	4.66	0	0	0	>4.66	0	0	0	>4.41	>4.91	>4.66	0	0	0	9	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, stick amp, fecal casts-far, shell bits
NNE0	C	6/21/2002	11:06	ST I	3 to 2 phi	1 to 0 phi	2 to 1 phi	SA.M	0	0	4.5	6.3	1.8	5.4	0	0	0	>5.40	0	0	0	>4.50	>6.30	>5.40	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand ripple, shell bits, tubes
NNE100	A	6/21/2002	10:57	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.14	6.02	2.88	4.58	0	0	0	>4.58	0	0	0	>3.14	>6.02	>4.58	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen. red sed patch @z, sand ripple, tubes
NNE100	B	6/21/2002	10:58	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.88	5.45	1.57	4.66	0	0	0	>4.66	0	0	0	>3.88	>5.45	>4.66	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sm tubes
NNE200	D	6/24/2002	10:59	ST II	> 4 phi	3 to 2 phi	> 4 phi	UN.SI	1	0.19	7.14	8.07	0.93	7.6	> 7.14	> 8.07	> 7.6	0.00	0	0	0	1.89	4.42	3.10	0	0	0	8	Physical	NO	Relic fine-grained DM >pen, shell bits, red clast, tubes, stick amps, burrow, red sed @z
NNE200	E	6/24/2002	10:59	ST II	> 4 phi	3 to 2 phi	> 4 phi	UN.SI	2	0.24	8.09	8.77	0.68	8.43	> 8.09	> 8.77	> 8.43	0.00	0	0	0	0.14	4.27	1.88	0	0	0	6	Biogenic	NO	Relic DM >pen, blk sulfidic sandy m, dense stick amps, ox clasts, m clasts-far, burrow opeing, fecal mound
NNE300	A	6/21/2002	10:44	ST II to III	> 4 phi	3 to 2 phi	> 4 phi	UN.SS	0	0	8.84	10.11	1.27	9.48	> 8.84	> 10.11	> 9.48	0.00	0	0	0	1.64	4.20	2.33	0	0	0	8	Biogenic	NO	Relic DM >pen, brn fine sand/blk sulfidic m, shell frags, Nucula, dense stick amps-mat, worms @z, surf reworking, tubes, burrowing anemone?
NNE300	B	6/21/2002	10:44	ST II	> 4 phi	3 to 2 phi	> 4 phi	UN.SS	1	1.1	8.5	9.11	0.61	8.81	> 8.5	> 9.11	> 8.81	0.00	0	0	0	0.14	4.34	1.35	0	0	0	5	Biogenic	NO	Relic DM >pen, tan fine sand mixed w/ blk sulfidic m, patchy RPD, dense stick amps, shell bits, worms @z, tubes, ox clast
NNW0	B	6/21/2002	09:53	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	5.68	7.34	1.66	6.51	0	0	0	>6.51	0	0	0	>5.68	>7.34	>6.51	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, sm tubes, shell bits
NNW0	C	6/21/2002	09:53	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.25	5.38	1.13	4.82	0	0	0	>4.82	0	0	0	>4.25	>5.38	>4.82	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, sand ripple, RPD>pen
NNW100	A	6/20/2002	15:47	ST I	> 4 phi	2 to 1 phi	4 to 3 phi	SA.F	0	0	11.04	11.96	0.92	11.5	0	0	4.85	6.73	0	0	0	4.00	6.80	5.48	0	0	0	7	Physical	NO	Uniform tan sand cap material over fine-grained blk relic dm, tubes, shell bits
NNW100	C	6/20/2002	15:48	ST I	> 4 phi	2 to 1 phi	3 to 2 phi	SA.F	1	0.59	6.71	9.32	2.61	8.01	0	0	1.03	7.11	0	0	0	1.28	8.96	4.52	0	0	0	7	Physical	NO	Cap sand over fine-grained blk relic dm, wiper clasts-obscured RPD, red clast, shell frags, fecal casts, sm tubes, red sed @z
NNW200	D	6/21/2002	09:43	ST I	> 4 phi	3 to 2 phi	> 4 phi	UN.SS	0	0	8.7	9.73	1.03	9.22	0	0	7.00	2.00	0	0	0	1.49	3.13	1.61	0	0	0	4	Physical	NO	Thin layer of cap sand over muddy relic DM, tan fine sand/blk sulfidic m, sand ripple, shell frags, tubes, red sed @z, surf rework, sm burrow-openings
NNW200	E	6/24/2002	11:16	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	6.16	7.52	1.36	6.84	0	0	1.05	5.26	0	0	0	4.55	6.47	4.37	0	0	0	7	Physical	NO	Uniform brn sand cap material over relic DM,sand ripple, red sed patches@z,shell bits,tubes-far
NNW300	A	6/20/2002	15:27	ST I	4 to 3 phi	< -1 phi	2 to 1 phi	SA.G	0	0	3.66	5.39	1.73	4.53	> 3.66	> 5.39	> 4.53	0.00	0	0	0	3.63	5.26	3.35	0	0	0	6	Physical	NO	Relic coarse-grained DM >pen, brn medium sand w/rocks & pebbles, shell frags, brick pieces, bryozoans
NNW300	C	6/20/2002	15:28	ST I	3 to 2 phi	1 to 0 phi	2 to 1 phi	SA.M	0	0	4.79	5.73	0.94	5.26	0	0	0	0.00	0	0	0	>4.79	>5.73	>5.26	0	0	0	7	Physical	NO	Ambient medium sand>pen, RPD >pen, tubes, sm brick pieces, stick amp-far, shell bits
NW0	B	6/20/2002	14:31	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.36	5.04	0.68	4.7	0	0	0	>4.70	0	0	0	>4.36	>5.04	>4.70	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, shell bits, sand ripple, fecal casts-far,tubes-far?
NW0	C	6/20/2002	14:32	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.25	6.89	2.64	5.57	0	0	0	>5.57	0	0	0	>4.25	>6.89	>5.57	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell frags
NW100	A	6/20/2002	14:38	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	5.61	6	0.39	5.81	0	0	0	>5.81	0	0	0	>5.61	>6.00	>5.81	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
NW100	B	6/20/2002	14:40	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.98	6.11	1.13	5.55	0	0	0	>5.55	0	0	0	>4.98	>6.11	>5.55	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
NW200	B	6/20/2002	14:45	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.62	6.62	3	5.12	0	0	0	>5.12	0	0	0	>3.62	>6.62	>5.12	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell bits
NW200	C	6/20/2002	14:46	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	5.59	6.48	0.89	6.03	0	0	0	>6.03	0	0	0	>5.59	>6.48	>6.03	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, tubes, fecal casts @ surf
NW300	B	6/20/2002	14:51	ST II	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	0	0	13.71	14.43	0.72	14.07	> 13.71	> 14.43	> 14.07	0.00	0	0	0	0.85	4.13	2.35	0	0	0	7	Physical	NO	Relic DM >pen, brn muddy fine sand/blk sulfidic m, partial pull away, tubes, Nucula, worm @z, shell bits, surf reworking
NW300	C	6/20/2002	14:52	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.14	5.88	3.74	4.01	0	0	0	0.00	0	0	0	0.07	5.75	2.85	0	0	0	5	Physical	NO	Tan ambient sand>pen, black mud=camera smear artifact, shell bits, wiper clasts, Nucula?
NW400	A	6/20/2002	15:14	ST I	> 4 phi	3 to 2 phi	4 to 3 phi	UN.SI	0	0	10.43	12.41	1.98	11.42	> 10.43	> 12.41	> 11.42	0.00	0	0	0	0.70	3.23	2.53	0	0	0	5	Indeterminate	NO	Relic DM >pen,tan muddy fine sand/blk sulfidic m,dist surf, rocks&brick pieces @ surf, burrows,shell frags, bryozoans,dewatering channels?, wht clay @z,flock lyr
NW400	B	6/20/2002	15:14	ST I	> 4 phi	< -1 phi	> 4 phi	HR	0	0	9.7	11.88	2.18	10.79	> 9.7	> 11.88	> 10.79	0.00	0	0	0	0.14	2.87	1.35	0	0	0	3	Physical	NO	Relic DM >pen, poorly sorted = rock & pebble over tan & blk muddy fine sand, red sed @ z, bryozoans, shell frags, brick pieces
NW500	C	6/20/2002	15:22	INDET	1 to 0 phi	< -1 phi	0 to -1 phi	HR	0	0	3.45	4.5	1.05	3.97	> 3.45	> 4.5	> 3.97	0.00	0	0	0	-99.00	-99.00	-99.00	0	0	0	99	Physical	NO	Relic DM >pen, Rock & pebbles mixed with coarse sand, brick pieces
NW500	D	6/24/2002	11:26	INDET	3 to 2 phi	< -1 phi	1 to 0 phi	HR	0	0	2.71	4.64	1.93	3.67	> 2.71	> 4.64	> 3.67	0.00	0	0	0	-99.00	-99.00	-99.00	0	0	0	99	Physical	NO	Relic DM >pen, Rock & pebbles over gry fine sand, shell frags, bryozoans
S0	A	6/20/2002	11:53	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.09	7.04	2.95	5.57	0	0	0	>5.57	0	0	0	>4.09	>7.04	>5.57	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
S0	C	6/20/2002	11:54	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	5.73	6.66	0.93	6.19	0	0	0	>6.19	0	0	0	>5.73	>6.66	>6.19	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple-far
S100	B	6/20/2002	11:47	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.41	5.45	2.04	4.43	0	0	0	>4.43	0	0	0	>3.41	>5.45	>4.43	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell frags-far
S100	C	6/20/2002	11:48	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.98	4.66	1.68	3.82	0	0	0	>3.82	0	0	0	>2.98	>4.66	>3.82	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell frags, tubes-far
S200	A	6/20/2002	11:42	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.46	5.46	2	4.46	0	0	0	>4.46	0	0	0	>3.46	>5.46	>4.46	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, stick amps-far, sand ripple?
S200	C	6/20/2002	11:43	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.77	5.04	2.27	3.9	0	0	0	>3.90	0	0	0	>2.77	>5.04	>3.90	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RDP >pen, sand ripple, tubes, shell frags-far
S300	A	6/20/2002	11:37	ST I	4 to 3 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	6.21	6.98	0.77	6.6	0	0	0	>6.60	0	0	0	2.73	4.98	3.82	0	0	0	7	Physical	NO	Cap sand>pen; black patches=wiper smear artifact, tubes-far, shell bits
S300	B	6/20/2002	11:37	ST I	3 to 2 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	4.71	6.71	2	5.71	0	0	0	>5.71	0	0	0	>4.71	>6.71	>5.71	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, tubes, sand ripple
S400	B	6/20/2002	11:33	ST II	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	0	0	13.73	14.2	0.47	13.97	> 13.73	> 14.2	> 13.97	0.00	0	0	0	0.07	5.33	2.45	0	0	0	7	Physical	NO	Soft muddy relic DM>pen, shell frags, stick amp, worm @z?, patchy RPD, Nucula?
S400	C	6/20/2002	11:33	ST II to III	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	2	0.2	11.68	12.02	0.34	11.85	> 11.68	> 12.02	> 11.85	0.00	0	0	0	1.07	3.84	2.09	0	0	0	7	Physical	NO	Soft muddy relic dm>pen, shell bits, tubes, ox clasts, burrowing anemone @z, starfish @surf
S500	A	6/20/2002	11:27	ST II to III	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	0	0	15.23	15.88	0.65	15.56	> 15.23	> 15.88	> 15.56	0.00	0	0	0	0.07	3.91	0.92	0	0	0	6	Biogenic	NO	Soft muddy relic DM>pen, Nucula, shell bits, stick amps, tubes, extensive burrow system, burrow opening, fecal lyrs-expelled sed, surf reworking, patchy RPD
S500	B	6/20/2002	11:27	ST II	> 4 phi	4 to 3 phi	> 4 phi	UN.SF	0	0	15.05	15.34	0.29	15.19	> 15.05	> 15.34	> 15.19	0.00	0	0	0	0.07	3.13	1.08	0	0	0	5	Biogenic	NO	Sof muddy blk relic DM >pen, shell bits, Nucula, stick amps?, Amp tube?, fecal lyr, patchy RPD,hydroid
S600	A	6/20/2002	11:18	ST II to III	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	0	0	15.48	15.88	0.4	15.68	> 15.48	> 15.88	> 15.68	0.00	0	0	0	1.21	5.19	2.25	0	0	0	7	Physical	NO	Soft muddy black relic dm>pen, dense Nucula, sm tubes, burrow, patchy RPD
S600	C	6/20/2002	11:20	ST II to III	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	3	0.13	14.45	14.89	0.44	14.67	> 14.45	> 14.89	> 14.67	0.00	0	0	0	0.28	5.83	2.15	0	0	0	7	Biogenic	NO	Soft black muddy DM>pen, Nucula, fecal casts, shell bits, surf reworking, fecal layer, burrowing anemone, stick amp?, ox & red clasts, patchy RPD, smear artifact
SE0	A	6/20/2002	09:55	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.12	4.16	1.04	3.64	0	0	0	>3.64	0	0	0	>3.12	>4.16	>3.64	0	0	0	6	Physical	NO	Brn sand cap material >pen, RPD>pen, shell frags, red sed=wiper clasts
SE0	B	6/20/2002	09:56	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.79	3.39	0.6	3.09	0	0	0	>3.09	0	0	0	>2.79	>3.39	>3.09	0	0	0	6	Physical	NO	Uniform tan sand cap material>pen, RPD >pen, worm @z, shell bits @surf
SE100	B	6/20/2002	10:01	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.88	6.45	2.57	5.16	0	0	0	>5.16	0	0	0	>3.88	>6.45	>5.16	0	0	0	7	Physical	NO	Uniform tan sand cap material>pen, RPD >pen
SE100	C	6/20/2002	10:02	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.04	5.73	1.69	4.89	0	0	0	>4.89	0	0	0	>4.04	>5.73	>4.89	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, fecal casts-far
SE200	A	6/20/2002	10:05	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.73	4.7	0.97	4.22	0	0	0	>4.22	0	0	0	>3.73	>4.70	>4.22	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sm tubes, shell bits, sand ripple?
SE200	C	6/20/2002	10:06	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	7.93	9.89	1.96	8.91	0	0	0	>8.91	0	0	0	4.42	7.50	5.78	0	0	0	7	Physical	NO	Uniform tan/gry sand cap material >pen, tubes, shell bits
SE300	A	6/20/2002	10:09	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.86	4.29	1.43	3.57	0	0	0	>3.57	0	0	0	>2.86	>4.29	>3.57	0	0	0	6	Physical	NO	Brn sand cap material >pen, shell frags, tubes, sand ripple-far
SE300	C	6/20/2002	10:11	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.52	5.54	3.02	4.03	0	0	0	>4.03	0	0	0	>2.52	>5.54	>4.03	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand ripple, shell bits
SE400	D	6/24/2002	10:34	ST II	> 4 phi	3 to 2 phi	> 4 phi	UN.SS	0	0	10.3	10.82	0.52	10.56	> 10.3	> 10.82	> 10.56	0.00	0	0	0	2.73	4.21	3.36	0	0	0	8	Biogenic	NO	Relic muddy black dm with well-developed RPD, stick amps, surf reworking, burrow openings, fecal mound, void lwr lft?, relic RPD?, org @surf?
SE400	E	6/24/2002	10:35	ST I	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	3	0.32	8.71	9.12	0.41	8.91	> 8.71	> 9.12	> 8.91	0.00	0	0	0	0.14	7.43	2.29	0	0	0	5	Physical	NO	Muddy relic blk dm>pen, sm tubes, red clasts, shell bits, worms @z
SE500	E	6/24/2002	10:30	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.29	5.14	2.85	3.71	0	0	0	0.00	0	0	0	>2.29	>5.14	>3.71	0	0	0	6	Physical	NO	Brn ambient sand >pen, shell bits, burrow opening?, sm tubes-far, fecal casts-far, RPD >pen
SE500	F	6/24/2002	10:30	INDET	3 to 2 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	0.73	1.41	0.68	1.07	0	0	0	0.00	0	0	0	-99.00	-99.00	-99.00	0	0	0	99	Physical	NO	Brn ambient sand >pen, underpen, image dark-original o.k.
SE600	D	6/24/2002	10:25	ST I	3 to 2 phi	< -1 phi	0 to -1 phi	SA.G	0	0	3.66	4.62	0.96	4.14	0	0	0	0.00	0	0	0	>3.66	>4.62	>4.14	0	0	0	7	Physical	NO	Ambient brn coarse sand & pebbles>pen, brick frags, shell frags, RPD >pen
SE600	E	6/24/2002	10:25	ST I	2 to 1 phi	0 to -1 phi	0 to -1 phi	SA.G	0	0	2.5	3.54	1.04	3.02	0	0	0	0.00	0	0	0	>2.50	>3.54	>3.02	0	0	0	6	Physical	NO	Ambient brn coarse sand & pebbles, RPD >pen, brick pieces, stick amps-far
SE700	A	6/20/2002	10:35	ST I	3 to 2 phi	2 to 1 phi	2 to 1 phi	SA.M	0	0	3.45	4.21	0.76	3.83	0	0	0	0.00	0	0	0	>3.45	>4.21	>3.83	0	0	0	7	Physical	NO	Ambient brn medium sand w/ sm silt fraction, RPD >pen, tubes, shell frags, hydroids?
SE700	D	6/24/2002	10:20	ST II	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.45	5.48	1.03	4.97	0	0	0	0.00	0	0	0	>4.45	>5.48	>4.97	0	0	0	9	Biogenic	NO	Ambient brn fine sand & silt, dense stick amps, RPD >pen, fecal layer, burrow opening?

Appendix A-1 (continued)

REMOTS Sediment- Profile Imaging Data from the 1997 Dioxin Mound Capping Project Area, June 2002 Survey

Station	Replicate	Date	Time	Successional Stage	Grain Size (phi) Min	Grain Size (phi) Max	Grain Size (phi) Maj Mode	Benthic Habitat	Mud Clasts Count	Mud Clasts Avg. Diam	Camera Penetration (cm) Min	Camera Penetration (cm) Max	Camera Penetration (cm) Range	Camera Penetration (cm) Mean	Dredged Material Thickness (cm) Min	Dredged Material Thickness (cm) Max	Dredged Material Thickness (cm) Mean	Cap Material Thickness (cm) Mean	Redox Rebound Thickness (cm) Min	Redox Rebound Thickness (cm) Max	Redox Rebound Thickness (cm) Mean	Apparent RPD Thickness (cm) Min	Apparent RPD Thickness (cm) Max	Apparent RPD Thickness (cm) Mean	Methane Count	Methane Mean	Methane Diam.	OSI	Surface Roughness	Low DO	Comments
SSE0	A	6/20/2002	10:44	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.59	5.93	1.34	5.26	0	0	0	>5.26	0	0	0	>4.59	>5.93	>5.26	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, tubes-far, sand ripple?
SSE0	C	6/20/2002	10:45	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	4	2.43	4.96	6.11	1.15	5.53	0	0	0	>5.53	0	0	0	>4.96	>6.11	>5.53	0	0	0	7	Physical	NO	Uniform tan sand cap material>pen, red sed=wiper clast, ox & red clsts, sand ripple,RPD>pen
SSE100	A	6/20/2002	11:01	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.84	5.54	0.7	5.19	0	0	0	0.00	0	0	0	>4.84	>5.54	>5.19	0	0	0	7	Physical	NO	Uniform brn ambient sand >pen, RPD >pen, shell bits, tubes-far
SSE100	C	6/20/2002	11:02	ST I	3 to 2 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	3.55	5.62	2.07	4.59	0	0	0	0.00	0	0	0	>3.55	>5.62	>4.59	0	0	0	7	Physical	NO	Uniform ambient brn muddy sand >pen, RPD >pen, sand ripple?, tubes, fecal casts?
SSE200	A	6/20/2002	11:06	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.79	5.82	1.03	5.31	0	0	0	0.00	0	0	0	>4.79	>5.82	>5.31	0	0	0	7	Physical	NO	Brn muddy ambient sand >pen, RPD >pen, sm tubes, sand ripple
SSE200	C	6/20/2002	11:07	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.93	4.73	1.8	3.83	0	0	0	0.00	0	0	0	1.54	3.58	2.51	0	0	0	5	Physical	NO	Brn ambient muddy sand >pen, sand ripple, tubes, shell frag, Nucula?
SSE300	B	6/20/2002	11:11	INDET	4 to 3 phi	1 to 0 phi	2 to 1 phi	SA.M	0	0	2.07	4.11	2.04	3.09	> 2.07	> 4.11	> 3.09	0.00	0	0	0	-99.00	-99.00	-99.00	0	0	0	99	Physical	NO	Brn&gry sand w/pebbles & brick=ambient or relic dm>pen, dist surf, shell frags
SSE300	C	6/20/2002	11:12	ST I	> 4 phi	3 to 2 phi	4 to 3 phi	UN.SS	0	0	2.48	3.86	1.38	3.17	> 2.48	> 3.86	> 3.17	0.00	0	0	0	0.07	2.85	1.44	0	0	0	3	Physical	NO	Relic DM >pen, tan&gry sand w/ brick & pebbles @surf, shell frags, tubes, wiper clast
SSW0	A	6/20/2002	12:00	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.11	6.89	2.78	5.5	0	0	0	>5.5	0	0	0	>4.11	>6.89	>5.5	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, tubes-far, shell frags, sand ripple
SSW0	C	6/20/2002	12:01	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.2	6.86	2.66	5.53	0	0	0	>5.53	0	0	0	>4.2	>6.86	>5.53	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RDP >pen, sand ripple, sm tubes
SSW100	A	6/20/2002	12:23	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.41	3.8	1.39	3.11	0	0	0	>3.11	0	0	0	>2.41	>3.80	>3.11	0	0	0	6	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, starfish @surf
SSW100	C	6/20/2002	12:24	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.98	6.04	3.06	4.51	0	0	0	>4.51	0	0	0	>2.98	>6.04	>4.51	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, starfish-far, shell bits, sand ripple
SSW200	A	6/20/2002	12:28	ST I	3 to 2 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.46	4.39	1.93	3.42	0	0	0	>3.42	0	0	0	>2.46	>4.39	>3.42	0	0	0	6	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand ripple, starfish-far, stick amp-far, shell bits
SSW200	C	6/20/2002	12:30	ST I	> 4 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	5.11	7.48	2.37	6.3	0	0	1.43	5.84	0	0	0	2.17	5.47	4.27	0	0	0	7	Physical	NO	Uniform tan sand cap lyr/fine-grained blk relic dm, sand ripple, sm tubes
SSW300	A	6/20/2002	12:33	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	1	1.35	4.45	5.95	1.5	5.2	0	0	0	>5.2	0	0	0	0.64	4.84	2.86	0	0	0	5	Physical	NO	Brn sand cap material >pen, 93 mound cap sand?, red sed @ surf=wiper clasts, shell bits
SSW300	C	6/20/2002	12:35	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.61	7.41	3.8	5.51	0	0	0	>5.51	0	0	0	>3.61	>7.41	>5.51	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand ripple, sm tubes
SW0	B	6/20/2002	13:14	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.46	4.43	0.97	3.94	0	0	0	>3.94	0	0	0	>3.46	>4.43	>3.94	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen
SW0	C	6/20/2002	13:14	ST I	3 to 2 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	5.39	5.96	0.57	5.68	0	0	0	>5.68	0	0	0	>5.39	>5.96	>5.68	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, shell bits, tubes
SW100	A	6/20/2002	13:07	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.84	5.18	2.34	4.01	0	0	0	>4.01	0	0	0	>2.84	>5.18	>4.01	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell bits, sm tubes-far
SW100	C	6/20/2002	13:09	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3	5.12	2.12	4.06	0	0	0	>4.06	0	0	0	>3.00	>5.12	>4.06	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand ripple, tubes
SW200	B	6/20/2002	13:03	ST I	3 to 2 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	5.41	7.89	2.48	6.65	0	0	0	>6.65	0	0	0	2.73	5.54	4.44	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, fecal casts?, sm tubes-far
SW200	C	6/20/2002	13:03	ST I	3 to 2 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	3.27	7.68	4.41	5.47	0	0	0	>5.47	0	0	0	1.92	7.61	4.40	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen. sm tubes-far, red sed @z, sand ripple/sloping topo?
SW300	A	6/20/2002	12:52	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.05	4.32	1.27	3.68	0	0	0	>3.68	0	0	0	>3.05	>4.32	>3.68	0	0	0	6	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, shell frags @ surf
SW300	C	6/20/2002	12:53	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.77	4.45	1.68	3.61	0	0	0	>3.61	0	0	0	>2.77	>4.45	>3.61	0	0	0	6	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, shell bits, sand ripple, shell @surf?
SW400	A	6/20/2002	12:46	ST I	> 4 phi	2 to 1 phi	4 to 3 phi	UN.SS	6	0.51	8.3	9.48	1.18	8.89	0	0	4.87	4.50	0	0	0	1.19	4.00	2.62	0	0	0	5	Physical	NO	Uniform tan sand cap material/fine-grained blk relic dm, sulfidic m @ z, sand ripple, ox & red clasts, sm tubes, fecal casts, shell bits
SW400	C	6/20/2002	12:47	ST I	3 to 2 phi	1 to 0 phi	2 to 1 phi	SA.M	0	0	3.25	4.79	1.54	4.02	0	0	0	>4.02	0	0	0	>3.25	>4.79	>4.02	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sm tubes
SW500	A	6/20/2002	12:39	ST II	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.57	5.29	2.72	3.93	0	0	0	>3.93	0	0	0	>2.57	>5.29	>3.93	0	0	0	9	Physical	NO	Uniform brn sand cap >pen, red sed patches@z, sand ripple,shell bits,stick amps,RPD>pen
SW500	C	6/20/2002	12:41	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.54	5.04	1.5	4.29	0	0	0	>4.29	0	0	0	>3.54	>5.04	>4.29	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, stick amp?, sand ripple
W0	B	6/19/2002	14:35	ST I	3 to 2 phi	1 to 0 phi	3 to 2 phi	SA.M	0	0	3.05	6.14	3.09	4.59	0	0	0	>4.59	0	0	0	>3.05	>6.14	>4.59	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, shell frags, sand ripple, sm tubes
W0	C	6/19/2002	14:36	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.41	5.12	0.71	4.76	0	0	0	>4.76	0	0	0	>4.41	>5.12	>4.76	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand dollar @ z, shell frags @ surf
W100	A	6/19/2002	14:28	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.45	6.11	2.66	4.78	0	0	0	>4.78	0	0	0	>3.45	>6.11	>4.78	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, tubes, shell bits
W100	C	6/19/2002	14:29	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.61	5.41	1.8	4.51	0	0	0	>4.51	0	0	0	>3.61	>5.41	>4.51	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
W200	B	6/19/2002	14:22	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	1.32	2.8	1.48	2.06	0	0	0	>2.06	0	0	0	>1.32	>2.80	>2.06	0	0	0	4	Physical	NO	Uniform tan sand cap material >pen, RPD> pen, underpen, sand ripple, sm tubes-far
W200	C	6/19/2002	14:22	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.59	4.66	1.07	4.12	0	0	0	>4.12	0	0	0	>3.59	>4.66	>4.12	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell bits
W300	B	6/19/2002	14:15	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.04	3.68	0.64	3.36	0	0	0	>3.36	0	0	0	>3.04	>3.68	>3.36	0	0	0	6	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, tubes-far?
W300	C	6/19/2002	14:16	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.04	5.34	1.3	4.69	0	0	0	>4.69	0	0	0	>4.04	>5.34	>4.69	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
W400	B	6/19/2002	14:07	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.66	4.38	1.72	3.52	0	0	0	>3.52	0	0	0	>2.66	>4.38	>3.52	0	0	0	6	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, sm tubes-far
W400	C	6/19/2002	14:08	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.14	5.12	2.98	3.63	0	0	0	>3.63	0	0	0	>2.14	>5.12	>3.63	0	0	0	6	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, sm tubes, shell bits
W500	B	6/19/2002	14:01	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.04	5.32	2.28	4.18	0	0	0	>4.18	0	0	0	>3.04	>5.32	>4.18	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
W500	C	6/19/2002	14:01	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.52	6.86	3.34	5.19	0	0	0	>5.19	0	0	0	>3.52	>6.86	>5.19	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
W600	B	6/19/2002	13:54	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.89	4.25	0.36	4.07	0	0	0	>4.07	0	0	0	>3.89	>4.25	>4.07	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen. RPD >pen, sand ripple
W600	C	6/19/2002	13:54	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.45	3.95	1.5	3.2	0	0	0	>3.20	0	0	0	>2.45	>3.95	>3.20	0	0	0	6	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
W700	B	6/19/2002	13:47	ST I	4 to 3 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	4.84	7.25	2.41	6.05	0	0	0	>6.05	0	0	0	>4.84	>7.25	>6.05	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell bits
W700	C	6/19/2002	13:47	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.48	6.11	2.63	4.8	0	0	0	4.80	0	0	0	2.10	4.21	2.97	0	0	0	5	Physical	NO	Uniform sand cap material >pen, tan/blk sand, shell bits, tubes, rippled sand, red sed patch@z
WNW0	B	6/20/2002	14:24	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.43	5.07	0.64	4.75	0	0	0	>4.75	0	0	0	>4.43	>5.07	>4.75	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
WNW0	C	6/20/2002	14:24	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.09	6.62	2.53	5.36	0	0	0	>5.36	0	0	0	>4.09	>6.62	>5.36	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell bits, tube or fecal cast-far
WNW100	B	6/20/2002	14:17	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.64	5.04	2.4	3.84	0	0	0	>3.84	0	0	0	>2.64	>5.04	>3.84	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple
WNW100	C	6/20/2002	14:18	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.59	7.11	2.52	5.85	0	0	0	>5.85	0	0	0	>4.59	>7.11	>5.85	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell bits
WNW200	A	6/20/2002	14:09	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	1.62	2.77	1.15	2.19	0	0	0	>2.19	0	0	0	>1.62	>2.77	>2.19	0	0	0	4	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, underpen, sand ripple, fecal casts-far?
WNW200	B	6/20/2002	14:10	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.11	5.27	1.16	4.69	0	0	0	>4.69	0	0	0	>4.11	>5.27	>4.69	0	0	0	7	Physical	NO	Uniform brn sand cap material >pen, RPD >pen, sand ripple
WNW300	B	6/20/2002	14:02	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.96	5.25	1.29	4.61	0	0	0	0.00	0	0	0	1.89	3.93	3.37	0	0	0	6	Physical	NO	Uniform brn ambient sand >pen, shell bits, starfish @ surf-far, sm tubes
WNW300	C	6/20/2002	14:03	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.5	6.07	3.57	4.28	0	0	0	0.00	0	0	0	>2.5	>6.07	>4.28	0	0	0	7	Physical	NO	Uniform tan ambient sand >pen, RPD >pen, sand ripple, shell bits, sm tubes?, fecal casts-far
WSW0	B	6/20/2002	13:20	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.21	5.86	2.65	4.53	0	0	0	>4.53	0	0	0	>3.21	>5.86	>4.53	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, red sed=wiper clast
WSW0	C	6/20/2002	13:20	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.61	6.34	2.73	4.97	0	0	0	>4.97	0	0	0	>3.61	>6.34	>4.97	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, shell bits
WSW100	A	6/20/2002	13:39	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.09	7.3	3.21	5.7	0	0	0	>5.70	0	0	0	>4.09	>7.30	>5.70	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple, tubes
WSW100	C	6/20/2002	13:40	ST I	3 to 2 phi	1 to 0 phi	3 to 2 phi	SA.F	0	0	6	7.25	1.25	6.62	0	0	0	>6.62	0	0	0	4.21	5.54	4.72	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, tubes, fecal casts?
WSW200	A	6/20/2002	13:44	ST II on III	> 4 phi	3 to 2 phi	> 4 phi	UN.SF	1	0.2	12.02	12.52	0.5	12.27	> 12.02	> 12.52	> 12.27	0.00	0	0	0	2.17	10.10	3.36	0	0	0	10	Physical	NO	Black muddy black relic dm>pen, blk sulfidic m @z, previous 93 Mound sand cap @ bottom?, shell bits, stick amps, void, ox clast, worms @z
WSW200	B	6/20/2002	13:47	ST I on III	> 4 phi	3 to 2 phi	> 4 phi	UN.SS	1	0.17	12.79	14.75	1.96	13.77	0	0	4.33	6.47	0	0	0	1.47	5.75	4.66	0	0	0	11	Physical	NO	Sed horizons - tan sand cap material/fine-grained blk relic DM/prevoius 93 Mound muddy sand cap material? , tubes, red clast, void, Nucula **Previous cap material=3.33 cm**
WSW300	A	6/20/2002	13:51	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.54	4.62	1.08	4.08	0	0	0	>4.08	0	0	0	>3.54	>4.62	>4.08	0	0	0	7	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sm tubes, sand ripple
WSW300	C	6/20/2002	13:54	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.55	4.66	2.11	3.61	0	0	0	>3.61	0	0	0	>2.55	>4.66	>3.61	0	0	0	6	Physical	NO	Uniform tan sand cap material >pen, RPD >pen, sand ripple

Appendix A-2
REMOTS Sediment-Profile Imaging Data from the South Reference Area, June 2002 Survey

Station	Replicate	Date	Time	Successional	Grain Size (phi)			Benthic	Mud Clasts		Camera Penetration (cm)				Dredged Material Thickness (cm)			Redox Rebound Thickness (cm)			Apparent RPD Thickness (cm)			Methane			OSI	Surface	Low	Comments
				Stage	Min	Max	Maj Mode	Habitat	Count	Avg. Diam	Min	Max	Range	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Count	Mean	Diam		Roughness	DO	
SREF10	A	6/21/2002	16:12	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.8	4.16	0.36	3.98	0	0	0	0	0	0	>3.8	>4.16	>3.98	0	0	0	7	Physical	NO	Homogenous ambient sand > pen. Small sand waves. RPD>pen
SREF10	C	6/21/2002	16:14	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.18	5.14	0.96	4.66	0	0	0	0	0	0	>4.18	>5.14	>4.66	0	0	0	7	Physical	NO	Homogenous ambient sand. Slightly muddy. Shell material in farfield. Small sand waves. RPD>pen
SREF11	B	6/21/2002	15:34	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	6.79	7.8	1.01	7.3	0	0	0	0	0	0	1.49	3.63	2.34	0	0	0	5	Physical	NO	Homogenous ambient sand > pen. Slight ripple.
SREF11	C	6/21/2002	15:35	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.5	5.66	1.16	5.08	0	0	0	0	0	0	>4.5	>5.66	>5.08	0	0	0	7	Physical	NO	Homogenous ambient sand > pen. Organism at depth? Slight ripple, Shell frag farfield. RPD>pen
SREF14	B	6/21/2002	15:27	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.77	4.84	1.07	4.31	0	0	0	0	0	0	>3.77	>4.84	>4.31	0	0	0	7	Physical	NO	Homogenous ambient sand > pen. Sand dollars in farfield. RPD>pen
SREF14	C	6/21/2002	15:30	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.23	4.84	0.61	4.53	0	0	0	0	0	0	>4.23	>4.84	>4.53	0	0	0	7	Physical	NO	Homogenous ambient sand > pen. RPD>pe
SREF16	B	6/21/2002	15:18	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	5.75	6.18	0.43	5.97	0	0	0	0	0	0	2.35	3.20	2.31	0	0	0	5	Physical	NO	Homogenous ambient sand > pen. Small tubes on surface.
SREF16	C	6/21/2002	15:19	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	2.66	4.21	1.55	3.43	0	0	0	0	0	0	>2.66	>4.21	>3.43	0	0	0	6	Physical	NO	Homogenous ambient sand > pen. RPD>pen Slight ripple.
SREF18	B	6/21/2002	15:13	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.32	4.71	0.39	4.52	0	0	0	0	0	0	>4.32	>4.71	>4.52	0	0	0	7	Physical	NO	Homogenous ambient sand > pen, shell material & possible surface orgs-far, RPD>pen
SREF18	C	6/21/2002	15:13	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	5.0	5.61	0.61	5.31	0	0	0	0	0	0	>5.0	>5.61	>5.31	0	0	0	7	Physical	NO	Homogenous ambient sand > pen. Possible organism tubes in farfield. RPD>pen
SREF20	A	6/21/2002	15:04	ST I	> 4 phi	3 to 2 phi	4 to 3 phi	SA.F	0	0	6.16	6.43	0.27	6.3	0	0	0	0	0	0	0.28	4.91	2.56	0	0	0	5	Physical	NO	Brown, ambient muddy fine sand, slightly reduced @ depth due to mud content, shell material @ surf.
SREF20	C	6/21/2002	15:07	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	5.88	6.34	0.46	6.11	0	0	0	0	0	0	>5.88	>6.34	>6.11	0	0	0	7	Physical	NO	Homogenous ambient sand > pen. Slight ripple in farfield. RPD>pen
SREF3	A	6/21/2002	16:02	ST I	4 to 3 phi	2 to 1 phi	2 to 1 phi	SA.M	0	0	7.89	8.36	0.47	8.12	0	0	0	0	0	0	>7.89	>8.36	>8.12	0	0	0	7	Physical	NO	Homogenous clean ambient medium sand > pen. Slight ripple. RPD>pen
SREF3	C	6/21/2002	16:03	ST I	4 to 3 phi	1 to 0 phi	2 to 1 phi	SA.M	0	0	2.89	5.73	2.84	4.31	0	0	0	0	0	0	>2.89	>5.73	>4.31	0	0	0	7	Physical	NO	Homogenous medium to coarse ambient sand >pen, shell material @ surf, sand wave, RPD>pen
SREF4	A	6/21/2002	14:53	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.55	3.8	0.25	3.67	0	0	0	0	0	0	>3.55	>3.8	>3.67	0	0	0	6	Physical	NO	Homogenous ambient sand > pen. Shell frags. Sand dollar in farfield. RPD>pen
SREF4	B	6/21/2002	14:54	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	6.41	6.66	0.25	6.53	0	0	0	0	0	0	>6.41	>6.66	>6.53	0	0	0	7	Physical	NO	Homogenous fine ambient sand > pen. RPD>pen
SREF5	A	6/21/2002	15:44	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	6.66	6.84	0.18	6.75	0	0	0	0	0	0	>6.66	>6.84	>6.75	0	0	0	7	Physical	NO	Homogenous ambient fine sand > pen. Sand dollars. RPD>pen
SREF5	B	6/21/2002	15:45	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	4.79	6.77	1.98	5.78	0	0	0	0	0	0	>4.79	>6.77	>5.78	0	0	0	7	Biogenic	NO	Homogenous ambient sand >pen, sand dollars, surf rough due to sand dollars,sand waves, RPD>pen
SREF8	A	6/21/2002	15:40	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	3.93	4.3	0.37	4.12	0	0	0	0	0	0	>3.93	>4.3	>4.12	0	0	0	7	Biogenic	NO	Homogenous ambient fine sand > pen. Sand dollar. RPD>pen
SREF8	B	6/21/2002	15:41	ST I	4 to 3 phi	2 to 1 phi	3 to 2 phi	SA.F	0	0	6.48	7.05	0.57	6.77	0	0	0	0	0	0	1.35	3.84	2.20	0	0	0	4	Physical	NO	Homogenous ambient sand > pen. Slightly muddy and slightly reduced@dep

Appendix B
Benthic Taxonomy Results

Appendix B-1.
Number of Individuals per square meter of Each Taxon Found at the Three South Reference Area Stations

Taxon Name	Station S4	Station S8	Station S14
Tubificidae (LPIL)	425	75	1350
Exogone hebes	150	25	1025
Polygordius (LPIL)	325	75	575
Pellucistoma (LPIL)	50	225	650
Nephtys picta	0	450	275
Mancocuma stellifera	225	175	75
Caulleriella sp. J	175	225	25
Aricidea catherinae	0	150	175
Rhepoxynius epistomus	100	150	50
Rhynchocoela (LPIL)	125	75	75
Tanaissus psammophilus	250	25	0
Monticellina dorsobranchialis	25	0	225
Nucula proxima	50	0	200
Unciola (LPIL)	250	0	0
Chiridotea tuftsi	0	0	225
Aricidea (LPIL)	200	0	0
Syllides longocirrata	25	50	100
Tellinidae (LPIL)	0	175	0
Tellina agilis	150	0	0
Chaetozone setosa	0	25	100
Hippomedon serratus	75	25	25
Pandora arenosa	50	50	25
Parougia caeca	25	25	75
Scoletoma acicularum	50	50	25
Glyceridae (LPIL)	100	0	0
Spiophanes bombyx	25	0	75
Cirratulidae (LPIL)	75	0	0
Edotea triloba	50	25	0
Maldanidae (LPIL)	75	0	0
Ampharete acutifrons	50	0	0
Aricidea wassi	0	0	50
Astarte borealis	0	50	0
Cerastoderma pinnulatum	50	0	0
Dulichia porrecta	0	50	0
Mytilus edulis	25	25	0
Nephtyidae (LPIL)	50	0	0
Nephtys (LPIL)	50	0	0
Paraonidae (LPIL)	25	25	0
Pitar morrhuanus	50	0	0
Scalibregma inflatum	0	0	50
Tellina (LPIL)	0	0	50
Ampelisca (LPIL)	25	0	0
Ampharetidae (LPIL)	0	25	0
Bivalvia (LPIL)	0	0	25
Byblis (LPIL)	0	0	25
Diastylis polita	0	0	25
Drilonereis longa	0	0	25
Echinarachnius parma	0	25	0
Echinoidea (LPIL)	0	25	0
Euchone elegans	25	0	0
Fimbriosthenelais minor	25	0	0
Glycera robusta	0	25	0
Ilyanassa trivittata	0	25	0
Lumbrinerides acuta	25	0	0
Mytilidae (LPIL)	0	25	0
Pitar (LPIL)	0	0	25
Protohaustorius wigleyi	25	0	0
Scoloplos armiger	0	25	0
Spionidae (LPIL)	25	0	0
Spisula solidissima	25	0	0

Appendix B-2.
Number of Individuals per square meter of Each
Taxon Found at the Six 1997 Mound Stations

	Station					
Taxon Name	E200	NE100	NW100	S200	SE100	W200
Pellucistoma (LPIL)	200	100	275	900	200	775
Polygordius (LPIL)	300	0	75	800	25	0
Nephtys picta	250	175	200	25	275	125
Diastylis polita	100	25	175	425	175	100
Edotea triloba	350	250	225	0	100	75
Exogone hebes	125	50	50	250	325	25
Nucula proxima	125	125	125	275	25	50
Spisula solidissima	200	175	175	0	50	50
Chiridotea tuftsi	125	275	25	0	50	75
Mancocuma stellifera	100	25	150	25	150	100
Tubificidae (LPIL)	25	75	125	0	175	50
Aricidea catherinae	75	0	250	0	25	25
Rhynchocoela (LPIL)	50	25	25	50	25	125
Spiophanes bombyx	25	25	100	75	75	0
Tellina agilis	25	25	50	100	25	50
Astarte borealis	0	0	0	275	0	0
Hippomedon serratus	0	125	75	25	25	25
Echinarachnius parma	125	25	0	0	0	50
Nephtyidae (LPIL)	0	0	0	175	0	0
Thracia conradi	150	25	0	0	0	0
Aricidea (LPIL)	125	0	0	25	0	0
Maldanidae (LPIL)	0	25	0	0	100	25
Bivalvia (LPIL)	75	50	0	0	25	0
Cerastoderma pinnulatum	50	0	25	25	25	0
Dulichia porrecta	50	0	0	25	50	0
Eusarsiella zostericola	25	0	25	50	0	0
Pitar morrhuanus	50	0	0	50	0	0
Glyceridae (LPIL)	50	0	0	50	0	0
Glycera (LPIL)	0	0	25	50	25	0
Travisia parva	25	25	0	25	0	25
Glycera robusta	75	0	0	0	0	0
Glycera americana	0	0	25	0	0	50
Parougia caeca	0	0	50	0	25	0
Scoletoma acicularum	50	25	0	0	0	0
Tellina (LPIL)	0	75	0	0	0	0
Unciola irrorata	0	0	25	25	0	0
Lyonsia hyalina	0	0	0	0	25	25
Pandora arenosa	0	0	25	0	0	25
Tharyx acutus	0	0	25	25	0	0
Monticellina dorsobranchialis	0	0	0	0	25	0
Amphipoda (LPIL)	0	0	0	0	25	0
Ampharetidae (LPIL)	0	0	25	0	0	0
Mytilus edulis	0	0	25	0	0	0
Yoldia limatula	0	0	0	25	0	0
Ilyanassa trivittata	0	0	0	0	0	25
Ampelisca (LPIL)	0	0	0	25	0	0
Axiothella mucosa	0	0	0	0	25	0
Calyptraeidae (LPIL)	0	0	0	0	25	0
Ensis directus	0	0	0	0	25	0
Fimbriosthenelais minor	0	0	0	0	0	25
Gastropoda (LPIL)	0	0	0	0	0	25
Glycera dibranchiata	0	25	0	0	0	0
Naticidae (LPIL)	0	0	25	0	0	0
Nephtys (LPIL)	0	0	0	0	25	0
Orbinia americana	0	0	0	0	0	25
Paraonidae (LPIL)	0	0	0	0	0	25
Polycirrus (LPIL)	0	0	25	0	0	0
Rhepoxynius epistomus	0	0	25	0	0	0
Sabellidae (LPIL)	0	0	0	25	0	0
Scalibregma inflatum	0	25	0	0	0	0
Sthenelais limicola	0	0	25	0	0	0
Terebellidae (LPIL)	0	0	0	25	0	0
Travisia (LPIL)	0	25	0	0	0	0
Unciola (LPIL)	0	25	0	0	0	0

Table B-3.
Number of Individuals per square meter of Each Taxon Found at the Three 1997 Off-Mound Stations

Taxon name	Station NE300	NE500	S500
Nucula proxima	2750	100000	58900
Nephtys incisa	0	450	650
Levinsenia gracilis	25	50	750
Monticellina dorsobranchialis	0	0	800
Scoletoma verrilli	250	375	50
Pherusa affinis	25	200	425
Cirratulidae (LPIL)	75	175	275
Cossura soyeri	0	125	375
Eusarsiella zostericola	225	75	100
Cerastoderma pinnulatum	175	0	200
Tubificidae (LPIL)	250	0	75
Actiniaria (LPIL)	0	75	250
Pitar morrhuanus	200	0	100
Phoronis (LPIL)	25	0	275
Diastylis polita	275	0	0
Pellucistoma (LPIL)	225	0	25
Ninoe nigripes	25	100	125
Rhynchocoela (LPIL)	100	50	50
Spiophanes bombyx	200	0	0
Tellina agilis	200	0	0
Aricidea catherinae	175	0	0
Polygordius (LPIL)	150	0	0
Leptosynapta tenuis	25	125	0
Nephtyidae (LPIL)	50	75	0
Lineidae (LPIL)	0	0	125
Exogone hebes	100	0	0
Dulichia porrecta	50	0	50
Mediomastus (LPIL)	25	0	75
Edotea triloba	50	0	25
Astarte borealis	75	0	0
Amphipoda (LPIL)	75	0	0
Aphelochaeta marioni	50	0	25
Scoletoma sp. AA	25	0	50
Nephtys picta	50	0	0
Aricidea (LPIL)	50	0	0
Glyceridae (LPIL)	50	0	0
Glycera robusta	50	0	0
Unciola irrorata	50	0	0
Ampharetidae (LPIL)	50	0	0
Mytilus edulis	50	0	0
Yoldia limatula	50	0	0
Ampelisca abdita	0	0	50
Chaetozone setosa	50	0	0
Mediomastus ambiseta	0	0	50
Photis macrocoxa	0	0	50
Spisula solidissima	25	0	0
Maldanidae (LPIL)	0	0	25
Glycera (LPIL)	25	0	0
Ilyanassa trivittata	25	0	0
Aoridae (LPIL)	0	25	0
Corophiidae (LPIL)	25	0	0
Cossuridae (LPIL)	0	0	25
Diastylis quadrispinosa	0	25	0
Erichthonius rubricornis	0	0	25
Euchone elegans	25	0	0
Philine quadrata	25	0	0
Phoxocephalus holbolli	25	0	0
Prionospio (LPIL)	0	0	25
Tubulanus (LPIL)	0	25	0

Appendix C
Core Analysis Results

Appendix C-1
Core Logs

The 2002 Survey of the 1997 Category II Mound

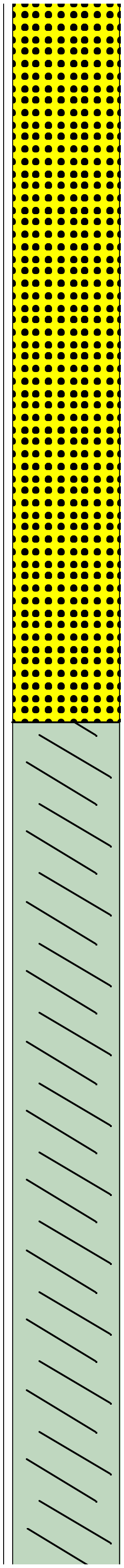
Survey: HARS Coring 2002
Core: 97A
Total Core Length: 288 cm

Longitude: -73.84271
Latitude: 40.37336
Cap Interface: 106 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0, -4, -8, -12, -16, -20, -24, -28, -32, -36, -40, -44, -48, -52, -56, -60, -64, -68, -72	0-106	dark gray lensed with black, marine odor, moist, hard, SAND					

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97A
Total Core Length: 288 cm
Longitude: -73.84271
Latitude: 40.37336
Cap Interface: 106 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-76 to -144	106-288	black mottled with gray, petroleum odor, moist, firm, CLAY	125-135	shell	75-77	Bulk Density, Water Content	
						85-87	Bulk Density, Water Content	
						94-99	Bulk Density, Grain Size - Sieve Only, Water Content	
						113-119	Bulk Density, Grain Size - w/Hydrometer, Shear Strength, Specific Gravity, Water Content	
						125-127	Bulk Density, Water Content	
						135-137	Bulk Density, Water Content	

Depth scale: -76, -80, -84, -88, -92, -96, -100, -104, -108, -112, -116, -120, -124, -128, -132, -136, -140, -144

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97A
Total Core Length: 288 cm

Longitude: -73.84271
Latitude: 40.37336
Cap Interface: 106 cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval		Analysis		Lithology
	-148				145-147	Bulk Density, Water Content	
	-152						
	-156		156-167	shell	155-157	Bulk Density, Water Content	
	-160						
	-164				165-167	Bulk Density, Water Content	
	-168						
	-172						
	-176				175-177	Bulk Density, Water Content	
	-180						
	-184						
	-188						
	-192						
	-196						
	-200						
	-204						
	-208						
	-212		212-215	shell			
	-216						

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97A
Total Core Length: 288 cm

Longitude: -73.84271
Latitude: 40.37336
Cap Interface: 106 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
				218-226	shell			
				279-283	shell			

Depth (cm): -220, -224, -228, -232, -236, -240, -244, -248, -252, -256, -260, -264, -268, -272, -276, -280, -284, -288

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97B
Total Core Length: 296 cm

Longitude: -73.84159
Latitude: 40.37232
Cap Interface: 97 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0 to -72	0-97	motteled tan and gray, no odor, moist, hard, SAND			64-70	PCDD/PCDF, TOC	
						66-68	Bulk Density, Water Content	

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97B
Total Core Length: 296 cm

Longitude: -73.84159
Latitude: 40.37232
Cap Interface: 97 cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval	Analysis	Lithology

Depth (cm): -76, -80, -84, -88, -92, -96, -100, -104, -108, -112, -116, -120, -124, -128, -132, -136, -140, -144, -148

Major Interval

Interval	Description
97-257	black, petroleum odor, moist, firm-hard, Silty CLAY

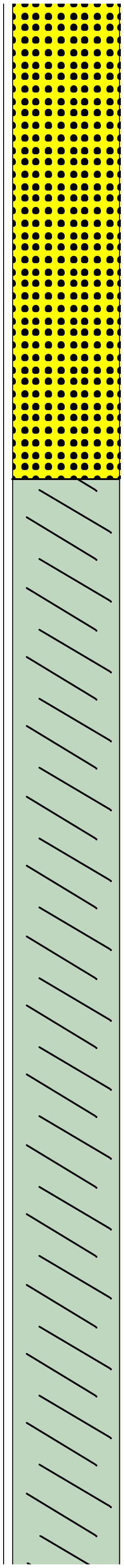
Sub-Interval

Interval	Description
79-97	lensed banded black and tan sand
114-122	shell
140-143	shell

Analysis

Interval	Analysis
76-78	Bulk Density, Water Content
84-90	Bulk Density, Grain Size - Sieve Only, PCDD/PCDF, TOC, Water Content
104-110	Bulk Density, Grain Size - w/Hydrometer, PCDD/PCDF, Shear Strength, Specific Gravity, TOC, Water Content
116-118	Bulk Density, Water Content
124-130	PCDD/PCDF, TOC
126-128	Bulk Density, Water Content
136-138	Bulk Density, Water Content
146-148	Bulk Density, Water Content

Lithology



The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97B
Total Core Length: 296 cm

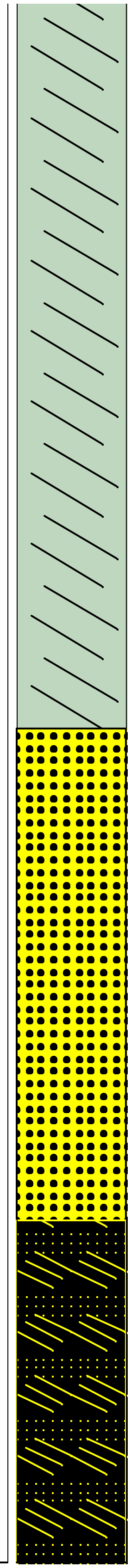
Longitude: -73.84159
Latitude: 40.37232
Cap Interface: 97 cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval		Analysis		Lithology
	-152						
	-156				156-158	Bulk Density, Water Content	
	-160						
	-164		162-165	lens of brown to redish brown, clayey silt			
	-168		165-220	lensed light brown to gray, silty clay	166-168	Bulk Density, Water Content	
	-172						
	-176						
	-180						
	-184						
	-188						
	-192						
	-196						
	-200						
	-204						
	-208						
	-212						
	-216						
	-220						

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97B
Total Core Length: 296 cm

Longitude: -73.84159
Latitude: 40.37232
Cap Interface: 97 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-224							
				226-231	rock			
	-228							
	-232							
	-236							
	-240							
	-244							
	-248							
	-252							
				254-257	very soft pocket of silty clay			
	-256							
		257-280	dark gray to black, petroleum odor, moist, hard, SAND					
	-260							
	-264							
	-268							
	-272							
	-276							
	-280	280-296	black, petroleum odor, moist, soft-firm, SAND AND CLAY					
	-284							
	-288							
	-292							
	-296							

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97C
Total Core Length: 234 cm

Longitude: -73.84054
Latitude: 40.3713
Cap Interface: 190 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0	0-102	tan to dark gray, no odor, moist, hard, SAND					
	-4							
	-8							
	-12							
	-16							
	-20							
	-24							
	-28							
	-32							
	-36							
	-40							
	-44							
	-48							
	-52							
	-56							

The 2002 Survey of the 1997 Category II Mound

Survey: **HARS Coring 2002**

Core: **97C**

Total Core Length: **234 cm**

Longitude: -73.84054

Latitude: 40.3713

Cap Interface: 190 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis	Lithology
	-60						
	-64						
	-68						
	-72						
	-76						
	-80						
	-84						
	-88						
	-92						
	-96						
	-100						
		102-190	banded tan to dark gray, no odor, moist, hard, SAND				
	-104						
	-108						
	-112						
	-116						

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97C
Total Core Length: 234 cm

Longitude: -73.84054
Latitude: 40.3713
Cap Interface: 190 cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval		Analysis	Lithology
	-120, -124, -128, -132, -136, -140, -144, -148, -152, -156, -160, -164, -168, -172, -176			159-161	Bulk Density, Water Content	
				169-171	Bulk Density, Water Content	

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97C
Total Core Length: 234 cm

Longitude: -73.84054
Latitude: 40.3713
Cap Interface: 190 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-180 -184 -188 -192 -196 -200 -204 -208 -212 -216 -220 -224 -228 -232					177-183	Bulk Density, Grain Size - Sieve Only, Water Content	
		190-234	black, slight marine odor, moist, firm-hard, CLAY					
						197-203	Bulk Density, Grain Size - w/Hydrometer, Shear Strength, Specific Gravity, Water Content	
				203-204	wood chip			
				208-217	dark gray sand lens			
						209-211	Bulk Density, Water Content	
						219-221	Bulk Density, Water Content	
						229-231	Bulk Density, Water Content	

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002

Core: 97D

Total Core Length: 282 cm

Longitude: -73.83932

Latitude: 40.37014

Cap Interface: 206 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0, -4, -8, -12, -16, -20, -24, -28, -32, -36, -40, -44, -48, -52, -56, -60, -64, -68	0-206	tan and gray, no odor, moist, hard, SAND					

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97D
Total Core Length: 282 cm

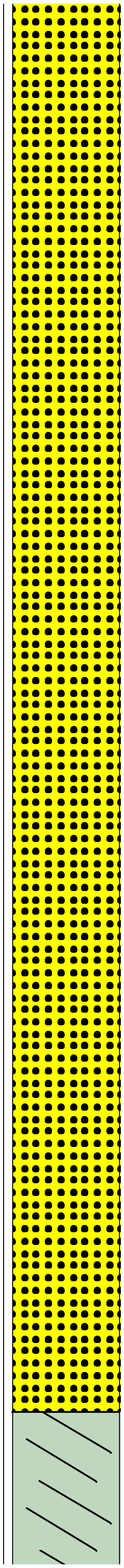
Longitude: -73.83932
Latitude: 40.37014
Cap Interface: 206 cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval	Analysis	Lithology
	-72 -76 -80 -84 -88 -92 -96 -100 -104 -108 -112 -116 -120 -124 -128 -132 -136 -140				

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97D
Total Core Length: 282 cm

Longitude: -73.83932
Latitude: 40.37014
Cap Interface: 206 cm

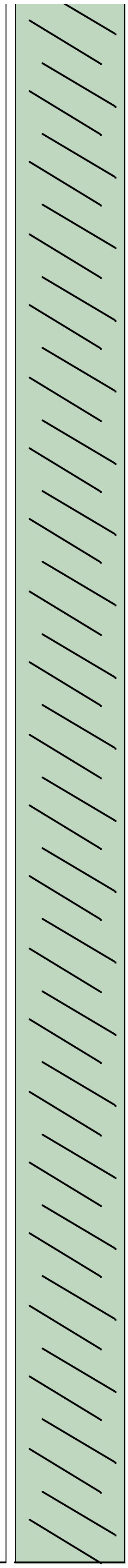
Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-144 to -212			144-206	lensed with black to gray sand	173-179	PCDD/PCDF, TOC	
						175-177	Bulk Density, Water Content	
						185-187	Bulk Density, Water Content	
						193-199	Bulk Density, Grain Size - Sieve Only, PCDD/PCDF, TOC, Water Content	
				197-211	dark greenish gray clay			
		206-282	black, petroleum odor, moist, firm-hard, CLAY					

Depth scale (cm): -144, -148, -152, -156, -160, -164, -168, -172, -176, -180, -184, -188, -192, -196, -200, -204, -208, -212

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97D
Total Core Length: 282 cm

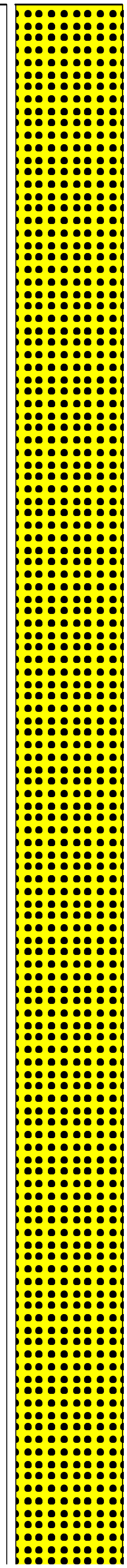
Longitude: -73.83932
Latitude: 40.37014
Cap Interface: 206 cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval		Analysis		Lithology
	-216, -220, -224, -228, -232, -236, -240, -244, -248, -252, -256, -260, -264, -268, -272, -276, -280		215-244	lensed dark greenish gray clay	213-219	Bulk Density, Grain Size - w/Hydrometer, PCDD/PCDF, Shear Strength, Specific Gravity, TOC, Water Content	
					225-227	Bulk Density, Water Content	
					233-239	PCDD/PCDF, TOC	
					235-237	Bulk Density, Water Content	
					245-247	Bulk Density, Water Content	
					255-257	Bulk Density, Water Content	
					265-267	Bulk Density, Water Content	
					275-277	Bulk Density, Water Content	

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97E
Total Core Length: 283 cm

Longitude: -73.83844
Latitude: 40.36912
Cap Interface: 143 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0, -4, -8, -12, -16, -20, -24, -28, -32, -36, -40, -44, -48, -52, -56, -60, -64, -68	0-143	tan to gray, no odor, moist, hard, SAND					

The 2002 Survey of the 1997 Category II Mound

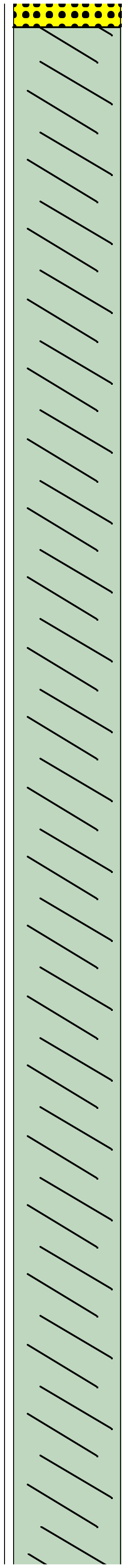
Survey: HARS Coring 2002
Core: 97E
Total Core Length: 283 cm

Longitude: -73.83844
Latitude: 40.36912
Cap Interface: 143 cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval		Analysis		Lithology
	-72						
	-76						
	-80						
	-84						
	-88						
	-92						
	-96						
	-100						
	-104						
	-108						
					110-116	PCDD/PCDF, TOC	
	-112				112-123	Bulk Density, Water Content	
	-116						
	-120						
			121-143	motteled very dark gray and black sand	122-124	Bulk Density, Water Content	
	-124						
	-128						
					130-136	Bulk Density, Grain Size - Sieve Only, PCDD/PCDF, TOC, Water Content	
	-132						
	-136						
	-140						

The 2002 Survey of the 1997 Category II Mound

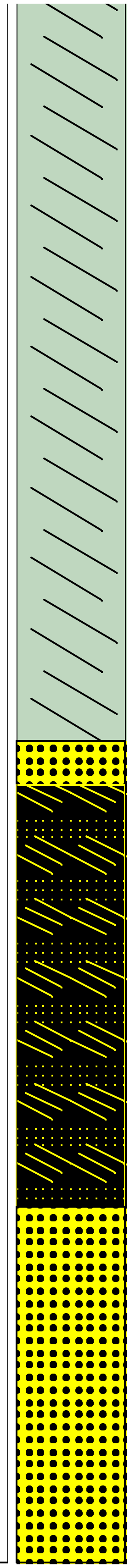
Survey: HARS Coring 2002
Core: 97E
Total Core Length: 283 cm
Longitude: -73.83844
Latitude: 40.36912
Cap Interface: 143 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-144 -148 -152 -156 -160 -164 -168 -172 -176 -180 -184 -188 -192 -196 -200 -204 -208 -212	143-246	black and dark greenish gray, petroleum, moist, firm-hard, CLAY			150-156	Bulk Density, Grain Size - w/Hydrometer, PCDD/PCDF, Specific Gravity, TOC, Water Content	
						159-163	Shear Strength	
						162-164	Bulk Density, Water Content	
						170-176	PCDD/PCDF, TOC	
						172-174	Bulk Density, Water Content	
						182-184	Bulk Density, Water Content	
						192-194	Bulk Density, Water Content	
						202-204	Bulk Density, Water Content	

The 2002 Survey of the 1997 Category II Mound

Survey: **HARS Coring 2002**
Core: **97E**
Total Core Length: **283 cm**

Longitude: -73.83844
Latitude: 40.36912
Cap Interface: 143 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-216, -220, -224, -228, -232, -236, -240, -244, -248, -252, -256, -260, -264, -268, -272, -276, -280					212-214	Bulk Density, Water Content	
		246-248	black and tan, petroleum odor, moist, soft, Clayey SAND					
		248-267	dark gray and black, petroleum odor, moist, soft-firm, SAND AND CLAY					
		267-283	black, petroleum odor, moist, hard, SAND					

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97L
Total Core Length: 280 cm

Longitude: -73.8393
Latitude: 40.37175
Cap Interface: 258 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0 to -68	0-193	tan, no odor, moist, hard, SAND	1-2	Sandollar			

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97L
Total Core Length: 280 cm

Longitude: -73.8393
Latitude: 40.37175
Cap Interface: 258 cm

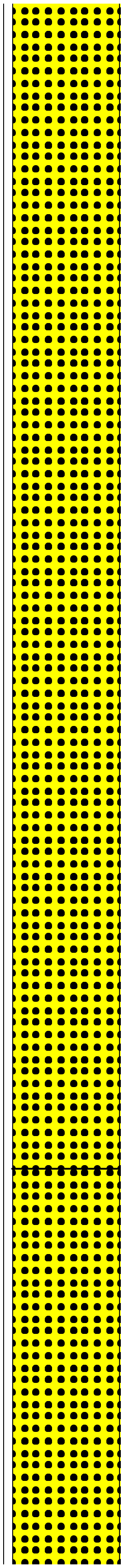
Core Photo	Depth (cm)	Major Interval	Sub-Interval	Analysis	Lithology

-72
-76
-80
-84
-88
-92
-96
-100
-104
-108
-112
-116
-120
-124
-128
-132
-136
-140

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97L
Total Core Length: 280 cm

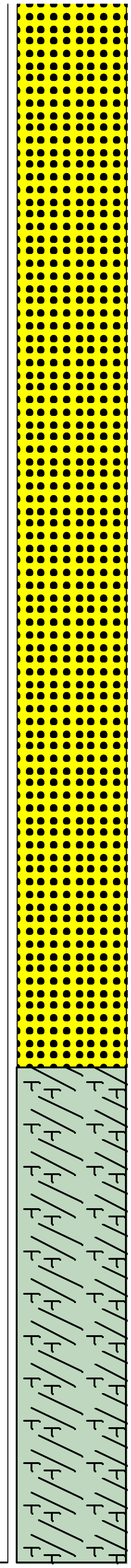
Longitude: -73.8393
Latitude: 40.37175
Cap Interface: 258 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis	Lithology
	-144 -148 -152 -156 -160 -164 -168 -172 -176 -180 -184 -188 -192 -196 -200 -204 -208	193- 258	banding tanish gray, no odor, moist, hard, SAND				

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97L
Total Core Length: 280 cm

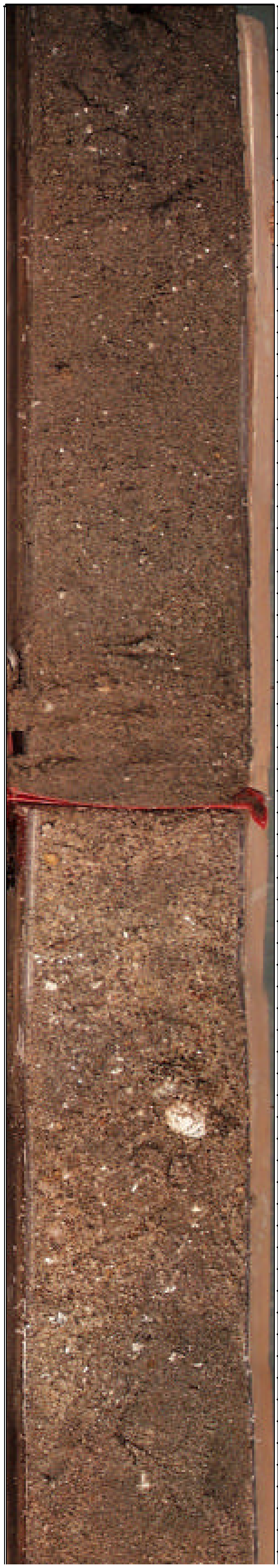
Longitude: -73.8393
Latitude: 40.37175
Cap Interface: 258 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-212 to -280							
						227-229	Bulk Density, Water Content	
						237-239	Bulk Density, Water Content	
						245-251	Bulk Density, Grain Size - Sieve Only, Water Content	
		258-280	black, petroleum odor, moist, soft-firm, SILTY CLAY					
						265-271	Bulk Density, Grain Size - w/Hydrometer, Shear Strength, Specific Gravity, Water Content	
				274-278	shell			
						277-279	Bulk Density, Water Content	

Depth scale: -212, -216, -220, -224, -228, -232, -236, -240, -244, -248, -252, -256, -260, -264, -268, -272, -276, -280

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97O
Total Core Length: 286 cm
Longitude: -73.84001
Latitude: 40.37045
Cap Interface: 260 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0, -4, -8, -12, -16, -20, -24, -28, -32, -36, -40, -44, -48, -52, -56, -60, -64, -68	0-160	grayish tan, no odor, moist, hard, SAND					

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97O
Total Core Length: 286 cm

Longitude: -73.84001
Latitude: 40.37045
Cap Interface: 260 cm

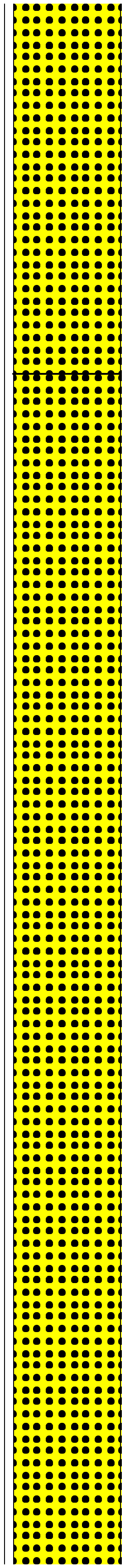
Core Photo	Depth (cm)	Major Interval	Sub-Interval	Analysis	Lithology

-72
-76
-80
-84
-88
-92
-96
-100
-104
-108
-112
-116
-120
-124
-128
-132
-136
-140

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97O
Total Core Length: 286 cm

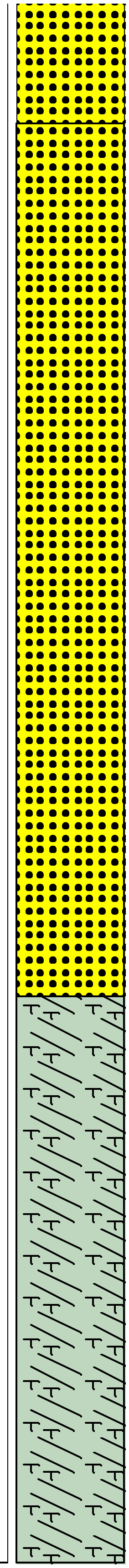
Longitude: -73.84001
Latitude: 40.37045
Cap Interface: 260 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis	Lithology
	-144 -148 -152 -156 -160 -164 -168 -172 -176 -180 -184 -188 -192 -196 -200 -204 -208 -212	160-220	motteled gray and tan, no odor, moist, hard, SAND				

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97O
Total Core Length: 286 cm

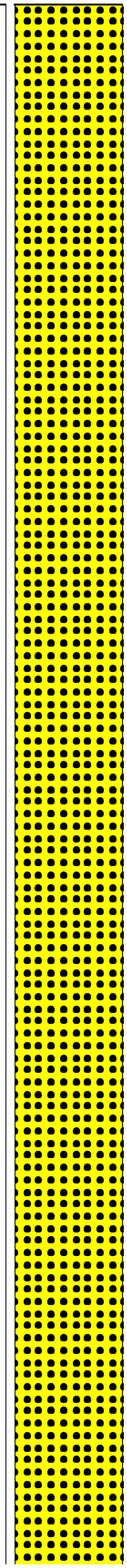
Longitude: -73.84001
Latitude: 40.37045
Cap Interface: 260 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-216, -220, -224, -228, -232, -236, -240, -244, -248, -252, -256, -260, -264, -268, -272, -276, -280, -284							
		220-260	dark gray, slight petroleum odor, moist, hard, SAND with Shell Fragments			229-231	Bulk Density, Water Content	
						239-241	Bulk Density, Water Content	
						247-253	Bulk Density, Grain Size - Sieve Only, Water Content	
		260-286	black, petroleum odor, moist, soft-firm, SILTY CLAY			262-268	Bulk Density, Grain Size - w/Hydrometer, Shear Strength, Specific Gravity, Water Content	
						279-281	Bulk Density, Water Content	

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97P
Total Core Length: 264 cm

Longitude: -73.8398
Latitude: 40.36934
Cap Interface: >264cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0, -4, -8, -12, -16, -20, -24, -28, -32, -36, -40, -44, -48, -52, -56, -60, -64	0-211	reddish-gray, marine odor, moist, hard, Sand			39-41	Bulk Density, Water Content	
						64-66	Bulk Density, Water Content	

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97P
Total Core Length: 264 cm

Longitude: -73.8398
Latitude: 40.36934
Cap Interface: >264cm

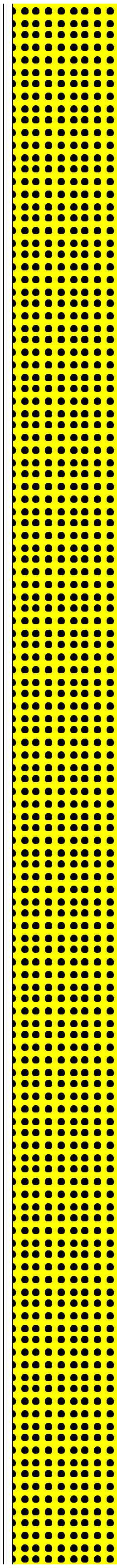
Core Photo	Depth (cm)	Major Interval	Sub-Interval		Analysis		Lithology
	-68 to -132		82-95	gray sand	87-93	Bulk Density, Grain Size - Sieve Only, Water Content	
					114-116	Bulk Density, Water Content	

Depth scale: -68, -72, -76, -80, -84, -88, -92, -96, -100, -104, -108, -112, -116, -120, -124, -128, -132

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97P
Total Core Length: 264 cm

Longitude: -73.8398
Latitude: 40.36934
Cap Interface: >264cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval		Analysis	Lithology
	-136					
	-140			139-141	Bulk Density, Water Content	
	-144					
	-148					
	-152					
	-156					
	-160					
	-164			162-168	Bulk Density, Grain Size - w/Hydrometer, Specific Gravity, Water Content	
	-168					
	-172					
	-176					
	-180					
	-184					
	-188					
	-192			189-191	Bulk Density, Water Content	
	-196					

The 2002 Survey of the 1997 Category II Mound

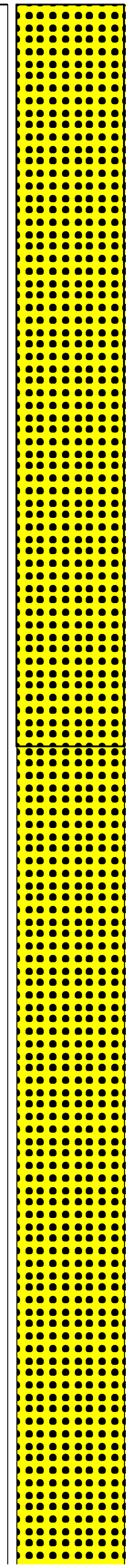
Survey: HARS Coring 2002
Core: 97P
Total Core Length: 264 cm

Longitude: -73.8398
Latitude: 40.36934
Cap Interface: >264cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-200							
	-204							
	-208							
	-212	211-294	gray, marine odor, moist, hard, SAND					
	-216					214-216	Bulk Density, Water Content	
	-220							
	-224							
	-228							
	-232							
	-236							
	-240							
	-244							
	-248							
	-252							
	-256							
	-260							
	-264							

The 2002 Survey of the 1997 Category II Mound

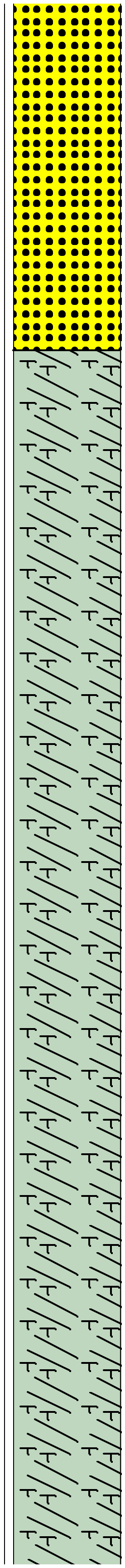
Survey: HARS Coring 2002
Core: 97Q
Total Core Length: 294 cm
Longitude: -73.84127
Latitude: 40.36943
Cap Interface: 90 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0, -4, -8, -12, -16, -20, -24, -28, -32	0-35	gray and tan, no odor, moist, hard, SAND					
	-36, -40, -44, -48, -52, -56	35-90	dark gray, slight petroleum odor, moist, hard, SAND					
						57-63	PCDD/PCDF, TOC	
	-60, -64, -68					59-61	Bulk Density, Water Content	
	-72					69-71	Bulk Density, Water Content	

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97Q
Total Core Length: 294 cm

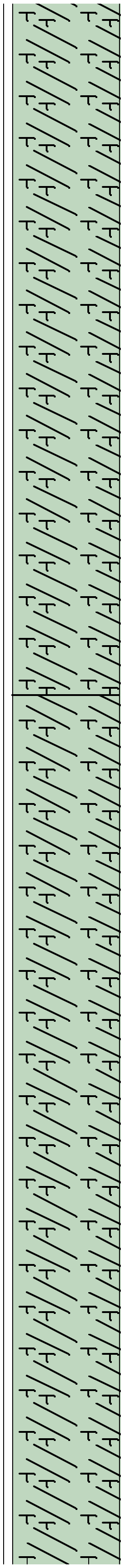
Longitude: -73.84127
Latitude: 40.36943
Cap Interface: 90 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-76, -80, -84, -88, -92, -96, -100, -104, -108, -112, -116, -120, -124, -128, -132, -136, -140, -144					77-83	Bulk Density, Grain Size - Sieve Only, PCDD/PCDF, TOC, Water Content	
		90-180	motteled dark gray and black, petroleum odor, moist, soft-firm, SILTY CLAY			97-103	Bulk Density, Grain Size - w/Hydrometer, PCDD/PCDF, Shear Strength, Specific Gravity, TOC, Water Content	
						109-111	Bulk Density, Water Content	
						117-123	PCDD/PCDF, TOC	
						119-121	Bulk Density, Water Content	
						129-131	Bulk Density, Water Content	
						139-141	Bulk Density, Water Content	

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97Q
Total Core Length: 294 cm

Longitude: -73.84127
Latitude: 40.36943
Cap Interface: 90 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-148, -152, -156, -160, -164, -168, -172, -176, -180, -184, -188, -192, -196, -200, -204, -208, -212, -216, -220					149-151	Bulk Density, Water Content	
						159-161	Bulk Density, Water Content	
		180-247	motteled dark gray and brown, organic odor, moist, soft-firm, SILTY CLAY					

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97Q
Total Core Length: 294 cm
Longitude: -73.84127
Latitude: 40.36943
Cap Interface: 90 cm

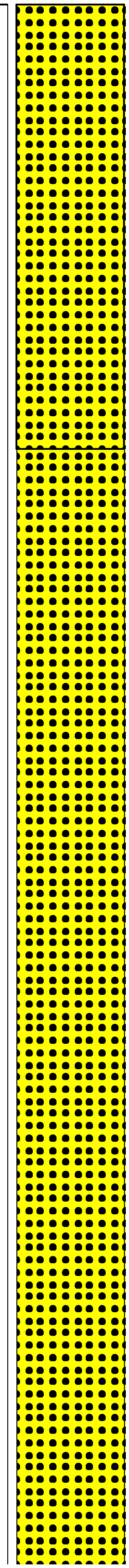
Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-224							
	-228							
	-232							
	-236							
	-240							
	-244							
	-248	247-294	motteled dark gray and black, petroleum odor, moist, soft-firm, SILTY CLAY					
	-252							
	-256							
	-260							
	-264							
	-268							
	-272							
	-276							
	-280							
	-284							
	-288							
	-292							

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97R
Total Core Length: 294 cm

Longitude: -73.83806
Latitude: 40.37104
Cap Interface: 152 cm

Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
0	0-21	grayish tan, no odor, moist, hard, SAND					
-4							
-8							
-12							
-16							
-20							
	21-152	gray, no odor, moist, hard, SAND					
-24							
-28							
-32							
-36							
-40							
-44							
-48							
-52							
-56							
-60							
-64							
-68							
-72							



The 2002 Survey of the 1997 Category II Mound

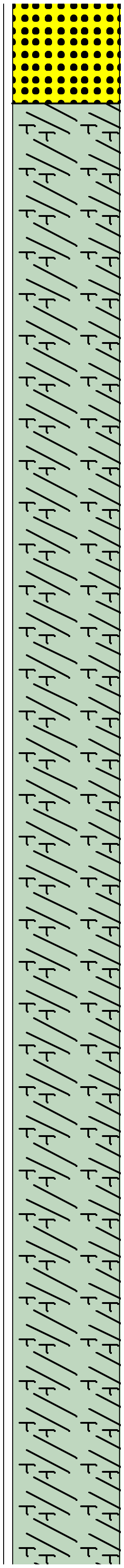
Survey: HARS Coring 2002
Core: 97R
Total Core Length: 294 cm
Longitude: -73.83806
Latitude: 40.37104
Cap Interface: 152 cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval	Analysis		Lithology
	-76					
	-80					
	-84					
	-88					
	-92					
	-96					
	-100					
	-104					
	-108					
	-112					
	-116					
	-120			119-125	PCDD/PCDF, TOC	
				121-123	Bulk Density, Water Content	
	-124					
	-128					
	-132			131-133	Bulk Density, Water Content	
	-136					
	-140			139-145	Bulk Density, Grain Size - Sieve Only, PCDD/PCDF, TOC, Water Content	
	-144					

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97R
Total Core Length: 294 cm

Longitude: -73.83806
Latitude: 40.37104
Cap Interface: 152 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-148 to -220	152-294	black, petroleum odor, moist, soft-firm, SILTY CLAY			159-165	Bulk Density, Grain Size - w/Hydrometer, PCDD/PCDF, Shear Strength, Specific Gravity, TOC, Water Content	
						171-173	Bulk Density, Water Content	
						179-185	PCDD/PCDF, TOC	
						181-183	Bulk Density, Water Content	
						191-193	Bulk Density, Water Content	
						201-203	Bulk Density, Water Content	
						211-213	Bulk Density, Water Content	

Depth scale: -148, -152, -156, -160, -164, -168, -172, -176, -180, -184, -188, -192, -196, -200, -204, -208, -212, -216, -220

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97R
Total Core Length: 294 cm

Longitude: -73.83806
Latitude: 40.37104
Cap Interface: 152 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-224 -228 -232 -236 -240 -244 -248 -252 -256 -260 -264 -268 -272 -276 -280 -284 -288 -292			225-234	large shell	221-223	Bulk Density, Water Content	

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97S
Total Core Length: 280 cm

Longitude: -73.84138
Latitude: 40.37169
Cap Interface: 223 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0 to -68	0-153	gray to tan, no odor, moist, hard, SAND	39-42	shell			

Depth scale (cm): 0, -4, -8, -12, -16, -20, -24, -28, -32, -36, -40, -44, -48, -52, -56, -60, -64, -68

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97S
Total Core Length: 280 cm

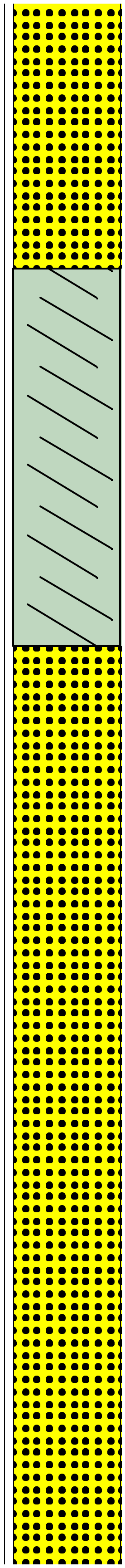
Longitude: -73.84138
Latitude: 40.37169
Cap Interface: 223 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis	Lithology
	-72, -76, -80, -84, -88, -92, -96, -100, -104, -108, -112, -116, -120, -124, -128, -132, -136, -140			115-153	banded dark gray sand		

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97S
Total Core Length: 280 cm

Longitude: -73.84138
Latitude: 40.37169
Cap Interface: 223 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-144 to -208	153-170	black, petroleum odor, moist, firm, CLAY with Sand			142-144	Bulk Density, Water Content	
		170-223	motteled tan and gray, no odor, moist, hard, SAND			192-194	Bulk Density, Water Content	
						202-204	Bulk Density, Water Content	

Depth scale (cm): -144, -148, -152, -156, -160, -164, -168, -172, -176, -180, -184, -188, -192, -196, -200, -204, -208

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97S
Total Core Length: 280 cm

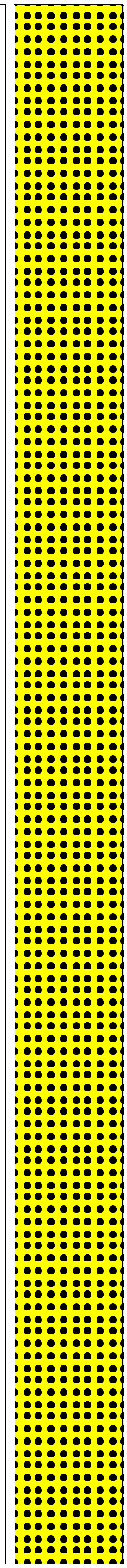
Longitude: -73.84138
Latitude: 40.37169
Cap Interface: 223 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-212 -216 -220 -224 -228 -232 -236 -240 -244 -248 -252 -256 -260 -264 -268 -272 -276 -280					212-214	Bulk Density, Grain Size - Sieve Only, Water Content	
		223-280	motteled black and greenish gray, petroleum odor, moist, firm-hard, CLAY			227-229	Bulk Density, Water Content	
						230-236	Bulk Density, Grain Size - w/Hydrometer, Shear Strength, Specific Gravity, Water Content	
						242-244	Bulk Density, Water Content	
						252-254	Bulk Density, Water Content	
						262-264	Bulk Density, Water Content	
				274-278	shell			

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97T
Total Core Length: 292 cm

Longitude: -73.84138
Latitude: 40.37061
Cap Interface: 130 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0 to -72	0-80	grayish-brown, marine odor, moist, hard, SAND	53-73	black sand streak			

Depth scale (cm): 0, -4, -8, -12, -16, -20, -24, -28, -32, -36, -40, -44, -48, -52, -56, -60, -64, -68, -72

Survey: HARS Coring 2002

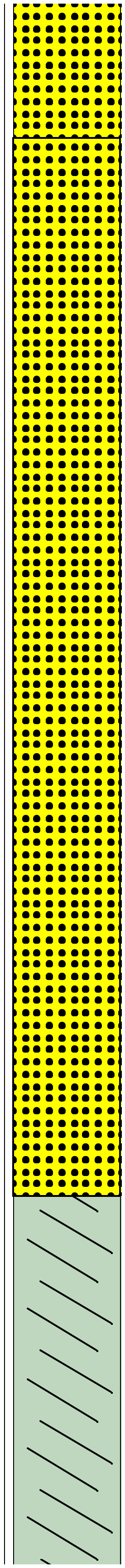
Core: 97T

Total Core Length: 292 cm

Longitude: -73.84138

Latitude: 40.37061

Cap Interface: 130 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval	Analysis		Lithology
	-76						
	-80	80-130	gray, marine odor, moist, hard, SAND				
	-84						
	-88						
	-92						
	-96						
	-100				99-101	Bulk Density, Water Content	
	-104						
	-108				109-111	Bulk Density, Water Content	
	-112						
	-116				117-123	Bulk Density, Grain Size - Sieve Only, Water Content	
	-120						
	-124						
	-128						
	-132	130-292	black mottled with gray, petroleum odor, moist, firm, CLAY				
	-136				137-143	Bulk Density, Grain Size - w/Hydrometer, Shear Strength, Specific Gravity, Water Content	
	-140						
	-144						

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002

Core: 97T

Total Core Length: 292 cm

Longitude: -73.84138

Latitude: 40.37061

Cap Interface: 130 cm

Core Photo | **Depth** (cm) | **Major Interval** | **Sub-Interval** | **Analysis** | **Lithology**

Depth (cm): -148, -152, -156, -160, -164, -168, -172, -176, -180, -184, -188, -192, -196, -200, -204, -208, -212, -216, -220

Sub-Interval	
176-180	shell
182-185	shell
194-199	shell

Analysis	
149-151	Bulk Density, Water Content
159-161	Bulk Density, Water Content
169-171	Bulk Density, Water Content
179-181	Bulk Density, Water Content
189-191	Bulk Density, Water Content
199-201	Bulk Density, Water Content

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97T
Total Core Length: 292 cm

Longitude: -73.84138
Latitude: 40.37061
Cap Interface: 130 cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval		Analysis	Lithology
	-224					
	-228		228-236	shell		
	-232					
	-236		237-241	shell		
	-240					
	-244					
	-248		249-255	rock		
	-252					
	-256					
	-260					
	-264					
	-268					
	-272					
	-276					
	-280					
	-284					
	-288					
	-292					

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002

Core: 97U

Total Core Length: 282 cm

Longitude: -73.83825

Latitude: 40.37327

Cap Interface: 113 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0, -4, -8, -12, -16, -20, -24, -28, -32, -36, -40, -44, -48, -52, -56, -60, -64, -68	0-113	dark gray, slight petroleum odor, moist, hard, SAND					

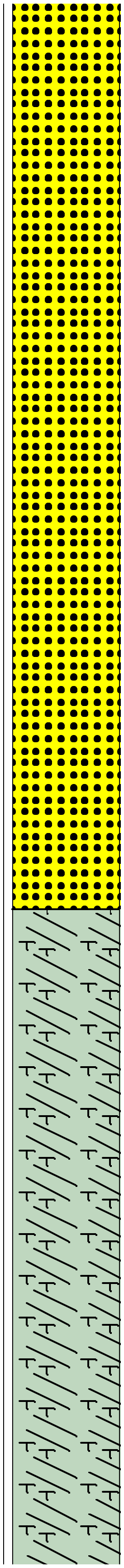
The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97U
Total Core Length: 282 cm
Longitude: -73.83825
Latitude: 40.37327
Cap Interface: 113 cm

Core Photo | **Depth (cm)** | **Major Interval** | **Sub-Interval** | **Analysis** | **Lithology**

Depth (cm): -72, -76, -80, -84, -88, -92, -96, -100, -104, -108, -112, -116, -120, -124, -128, -132, -136, -140

Major Interval		Sub-Interval		Analysis	
				80-86	PCDD/PCDF, TOC
				82-84	Bulk Density, Water Content
				93-94	Bulk Density, Water Content
				100-106	Bulk Density, Grain Size - Sieve Only, PCDD/PCDF, TOC, Water Content
113-188	black with dark gray bands, petroleum odor, moist, soft-firm, Sandy SILTY CLAY				
				120-126	Bulk Density, Grain Size - w/Hydrometer, PCDD/PCDF, Shear Strength, Specific Gravity, TOC, Water Content
		131-133	light gray silty band		
				132-134	Bulk Density, Water Content
		140-141	light gray silty band	140-146	PCDD/PCDF, TOC



The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97U
Total Core Length: 282 cm

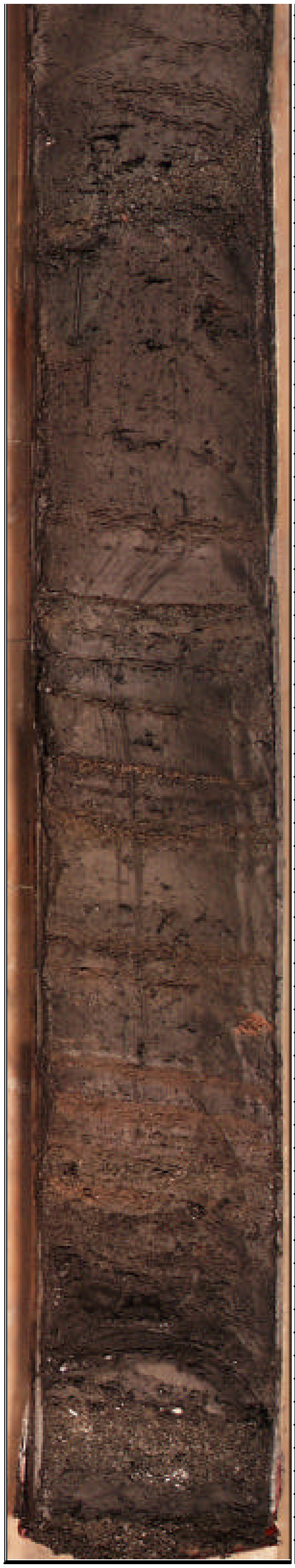
Longitude: -73.83825
Latitude: 40.37327
Cap Interface: 113 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	-144					142-144	Bulk Density, Water Content	
				145-146	redish black silty band			
	-148							
	-152					152-154	Bulk Density, Water Content	
	-156							
	-160							
	-164					162-164	Bulk Density, Water Content	
	-168							
	-172					172-174	Bulk Density, Water Content	
	-176							
	-180							
	-184					182-184	Bulk Density, Water Content	
	-188	188-202	black , petroleum odor, moist, hard, SAND					
	-192							
	-196							
	-200							
	-204	202-237	black, petroleum odor, moist, soft-firm, Sandy SILTY CLAY					
	-208							
	-212							

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97U
Total Core Length: 282 cm
Longitude: -73.83825
Latitude: 40.37327
Cap Interface: 113 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis	Lithology



Depth (cm): -216, -220, -224, -228, -232, -236, -240, -244, -248, -252, -256, -260, -264, -268, -272, -276, -280

Major Interval

237-271	banded redish black and tan, petroleum odor, moist, soft-firm, Sandy SILTY CLAY
271-282	black, petroleum odor, moist, soft-firm, SILTY CLAY and Sand

Sub-Interval

241-243	black sand band
249-250	light tan sand band
251-252	light tan sand band
256-257	dark gray sand band
261-262	redish black silty band
264-265	redish black silty band
267-268	dark gray sand band
276-280	gray sand band

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002

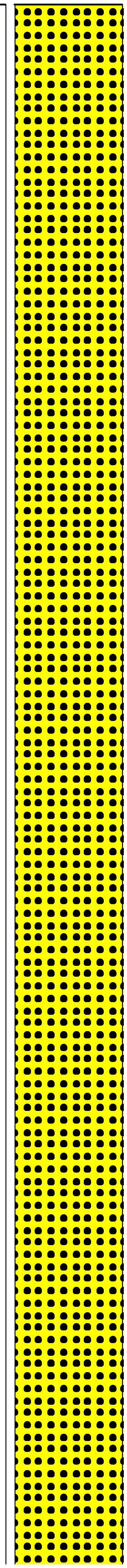
Core: 97V

Total Core Length: 291 cm

Longitude: -73.84179

Latitude: 40.36693

Cap Interface: 203 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology
	0, -4, -8, -12, -16, -20, -24, -28, -32, -36, -40, -44, -48, -52, -56, -60, -64, -68, -72	0-178	reddish-gray, marine odor, moist, hard, SAND					

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002

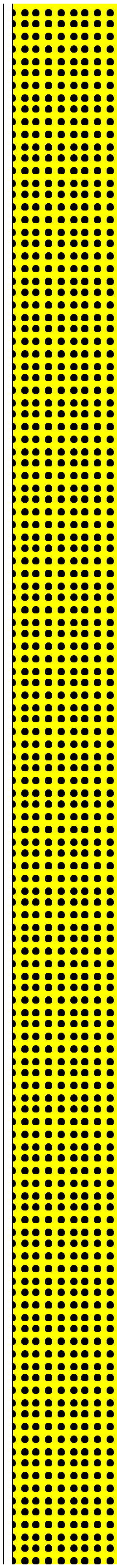
Core: 97V

Total Core Length: 291 cm

Longitude: -73.84179

Latitude: 40.36693

Cap Interface: 203 cm

Core Photo	Depth (cm)	Major Interval	Sub-Interval		Analysis	Lithology
	-76					
	-80					
	-84					
			85-93	black clay with marine odor		
	-88					
	-92					
	-96					
	-100					
	-104					
	-108					
	-112					
	-116					
	-120					
	-124					
	-128					
	-132					
	-136					
	-140					
	-144					

The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97V
Total Core Length: 291 cm

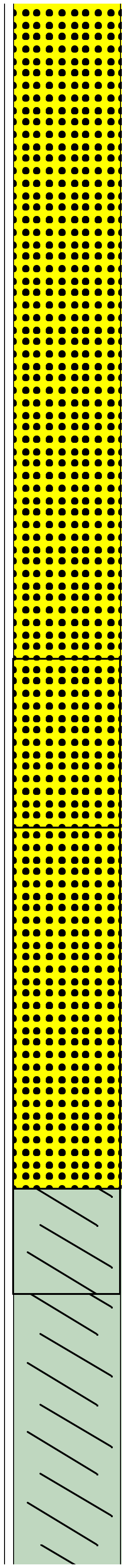
Longitude: -73.84179
Latitude: 40.36693
Cap Interface: 203 cm

Core Photo | **Depth (cm)** | **Major Interval** | **Sub-Interval** | **Analysis** | **Lithology**

Depth (cm): -148, -152, -156, -160, -164, -168, -172, -176, -180, -184, -188, -192, -196, -200, -204, -208, -212, -216, -220

Major Interval	Description	Sub-Interval	Description
178-186	black, marine odor, moist, hard, SAND	178-186	shell
		181-182	black clay
186-203	light to dark gray, petroleum odor, moist, hard, SAND		
203-208	black, petroleum odor, moist, firm, Sandy CLAY		
208-223	black, petroleum odor, moist, firm, CLAY with Sand		

Analysis Interval	Analysis
172-174	Bulk Density, Water Content
182-184	Bulk Density, Water Content
190-196	Bulk Density, Grain Size - Sieve Only, Water Content
210-216	Bulk Density, Grain Size - w/Hydrometer, Shear Strength, Specific Gravity, Water Content



The 2002 Survey of the 1997 Category II Mound

Survey: HARS Coring 2002
Core: 97V
Total Core Length: 291 cm

Longitude: -73.84179
Latitude: 40.36693
Cap Interface: 203 cm

Core Photo	Depth (cm)	Major Interval		Sub-Interval		Analysis		Lithology

Depth (cm): -224, -228, -232, -236, -240, -244, -248, -252, -256, -260, -264, -268, -272, -276, -280, -284, -288

Major Interval

223-234	black, petroleum odor, moist, firm, CLAY
234-272	dark gray, petroleum odor, moist, hard, SAND
272-279	black, petroleum odor, moist, firm, CLAY
279-288	black, petroleum odor, moist, firm, Clayey SAND
288-291	black, petroleum odor, moist, firm, CLAY

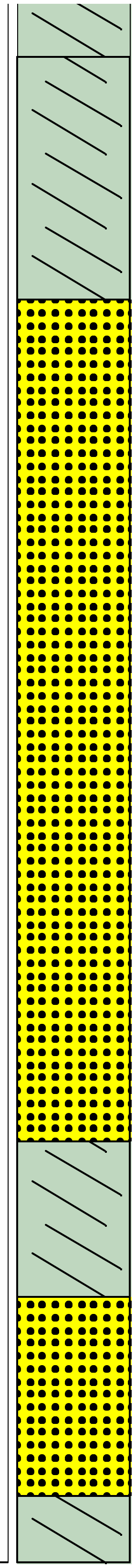
Sub-Interval

258-260	shell
281-283	black clay

Analysis

222-224	Bulk Density, Water Content
232-234	Bulk Density, Water Content
242-244	Bulk Density, Water Content
252-254	Bulk Density, Water Content
262-264	Bulk Density, Water Content
272-274	Bulk Density, Water Content

Lithology



Appendix C-2
Summary of Physical Properties for Cap Material and Dredged Material

Summary of Physical Properties for Cap Material

Client Sample ID	Gravel >#4 (%)	Coarse Sand #10 (%)	Medium Sand #20-#40 (%)	Fine Sand #60-#200 (%)	Silt 0.074-0.005 mm (%)	Clay <0.005 mm (%)	Passing No. 200 <0.074 mm (%)	USCS Classification
97B+87	0.00	0.64	19.82	78.96	-	-	0.58	SP
97C+180	0.00	0.12	20.91	78.69	-	-	0.28	SP
97D+196	0.17	0.25	14.77	84.27	-	-	0.53	SP
9.70E+134	1.18	1.63	20.89	75.91	-	-	0.39	SP
97L+248	0.73	1.51	24.35	72.96	-	-	0.46	SP
97O+250	1.37	1.35	19.83	76.75	-	-	0.70	SP
97Q+80	0.94	1.73	13.08	83.76	-	-	0.48	SP
97R+142	0.06	1.79	16.97	80.63	-	-	0.54	SP
97U+103	1.10	2.60	30.96	65.08	-	-	0.26	SP
97A+96	0.08	1.13	19.82	78.37	-	-	0.60	SP
97P+90	0.27	0.93	26.19	72.39	-	-	0.22	SP
97P+165	0.00	2.27	35.99	57.81	0.75	3.18	-	SP
97S+213	0.11	0.51	11.73	86.91	-	-	0.73	SP
97T+120	0.49	0.44	18.37	80.41	-	-	0.29	SP
97V+193	0.22	0.50	19.91	79.12	-	-	0.24	SP

Summary of Physical Properties for Dredged Material

Client Sample ID	Gravel >#4 (%)	Coarse Sand #10 (%)	Medium Sand #20-#40 (%)	Fine Sand #60-#200 (%)	Silt 0.074-0.005 mm (%)	Clay <0.005 mm (%)	Passing No. 200 <0.074 mm (%)	USCS Classification
97B-107	0.29	0.67	5.50	19.72	39.83	34.00	-	ML
97C-200	0.00	0.11	5.37	15.26	41.27	38.00	-	ML
97D-216	0.00	0.34	2.17	7.84	49.40	40.25	-	ML
97E-153	0.00	0.04	1.18	10.76	53.02	35.00	-	ML
97L-268	0.00	0.56	2.63	19.14	45.17	32.50	-	ML
97Q-100	0.00	0.03	0.82	10.32	54.84	34.00	-	ML
97O-265	0.00	0.00	2.41	23.70	43.88	30.00	-	ML
97R-162	0.48	0.61	0.87	12.67	42.37	43.00	-	CL
97U-123	0.00	0.19	1.93	13.88	45.00	39.00	-	ML
97A-116	0.10	0.23	1.24	11.61	52.32	34.50	-	ML
97S-233	0.00	0.10	2.63	9.22	50.05	38.00	-	ML
97T-140	1.54	5.01	16.15	16.73	36.56	24.00	-	ML
97V-213	13.33	4.60	29.13	29.28	8.66	15.00	-	SC

Appendix C-3
Sediment Water Content, Density, and Specific Gravity in Each Core Subsample

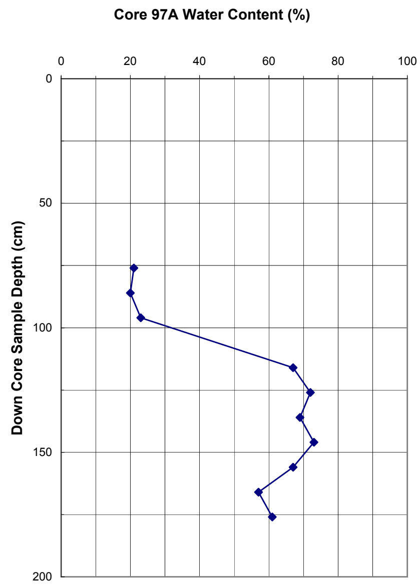
Table C-3
Sediment Water Content, Density, and Specific Gravity Results

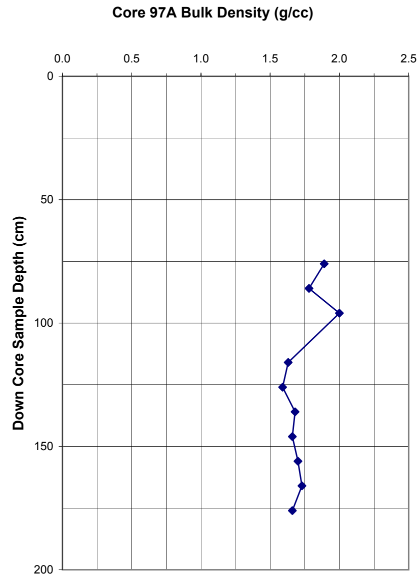
SAIC Sample ID	AMS Sample ID	W_c (%)	W_c-Salt Corrected (%)	Depth (cm)	Wet Unit Wt. (g/cm^3)	Depth (cm)	Dry Unit Wt. (g/cm^3)	G_s
97B+67	12028	21	22	67	1.74	67	1.44	-
97B+77	12029	20	21	77	1.75	77	1.46	-
97B+87	12030	19	20	87	1.75	87	1.46	-
97B-107	12031	52	56	107	1.72	107	1.13	2.67
97B-117	12032	55	58	117	1.74	117	1.12	-
97B-127	12033	59	63	127	1.68	127	1.06	-
97B-137	12034	50	53	137	1.75	137	1.16	-
97B-147	12035	45	47	147	1.78	147	1.23	-
97B-157	12036	43	45	157	1.82	157	1.27	-
97B-167	12037	60	64	167	1.66	167	1.04	-
97C+160	12038	23	24	160	1.75	160	1.42	-
97C+170	12039	19	20	170	1.74	170	1.47	-
97C+180	12040	21	22	180	1.81	180	1.49	-
97C-200	12041	57	60	200	1.73	200	1.10	2.68
97C-210	12042	35	37	210	1.79	210	1.33	-
97C-220	12043	55	59	220	1.70	220	1.09	-
97C-230	12044	60	64	230	1.64	230	1.02	-
97D+176	12045	21	22	176	1.72	176	1.42	-
97D+186	12046	20	21	186	1.82	186	1.51	-
97D+196	12047	21	22	196	1.81	196	1.50	-
97D-216	12048	65	69	216	1.65	216	1.00	2.67
97D-226	12049	67	71	226	1.67	226	1.00	-
97D-236	12050	67	71	236	1.64	236	0.98	-
97D-246	12051	62	65	246	1.66	246	1.03	-
97D-256	12052	61	64	256	1.68	256	1.05	-
97D-266	12053	60	64	266	1.68	266	1.05	-
97D-276	12054	55	59	276	1.69	276	1.09	-
97E+115	12055	17	18	115	1.71	115	1.45	-
97E+123	12056	21	22	123	1.85	123	1.53	-
97E+133	12057	20	20	133	1.75	133	1.46	-
97E-153	12058	59	62	153	1.71	153	1.08	2.66
97E-163	12059	63	67	163	1.66	163	1.02	-
97E-173	12060	66	71	173	1.64	173	0.99	-
97E-183	12061	71	75	183	1.60	183	0.94	-
97E-193	12062	79	84	193	1.54	193	0.86	-
97E-203	12063	69	73	203	1.60	203	0.95	-
97E-213	12064	61	64	213	1.68	213	1.05	-
97L+228	12065	19	19	228	1.71	228	1.44	-
97L+238	12066	20	21	238	1.70	238	1.42	-
97L+248	12067	18	19	248	1.71	248	1.44	-
97L-268	12068	53	57	268	1.81	268	1.18	2.68
97L-278	12069	52	55	278	1.77	278	1.16	-
97O+230	12070	22	22	230	1.79	230	1.47	-
97O+240	12071	20	21	240	1.80	240	1.50	-
97O+250	12072	20	21	250	1.77	250	1.47	-
97O-265	12073	44	47	265	1.83	265	1.27	2.69
97O-280	12074	51	54	280	1.72	280	1.14	-
97Q+60	12075	19	20	60	1.78	60	1.50	-
97Q+70	12076	21	21	70	1.83	70	1.52	-
97Q+80	12077	20	20	80	1.72	80	1.43	-
97Q-100	12078	58	62	100	1.72	100	1.08	2.68
97Q-110	12079	68	72	110	1.60	110	0.95	-
97Q-120	12080	82	87	120	1.55	120	0.85	-
97Q-130	12081	62	66	130	1.65	130	1.02	-
97Q-140	12082	63	66	140	1.65	140	1.01	-
97Q-150	12083	64	68	150	1.66	150	1.01	-
97Q-160	12084	67	71	160	1.65	160	0.99	-
97R+122	12085	20	21	122	1.73	122	1.44	-
97R+132	12086	19	20	132	1.74	132	1.45	-
97R+142	12087	21	22	142	1.76	142	1.46	-
97R-162	12088	74	79	162	1.59	162	0.91	2.65
97R-172	12089	78	83	172	1.58	172	0.89	-

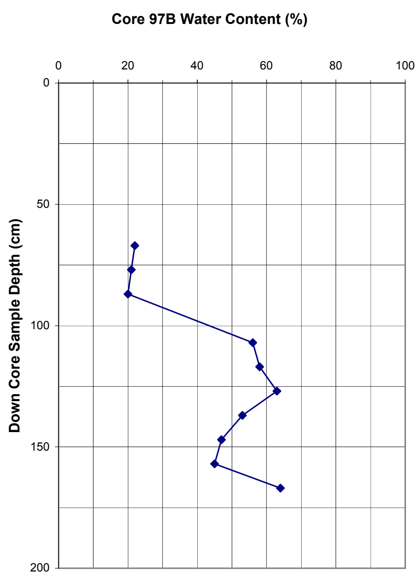
Table C-3
Sediment Water Content, Density, and Specific Gravity Results

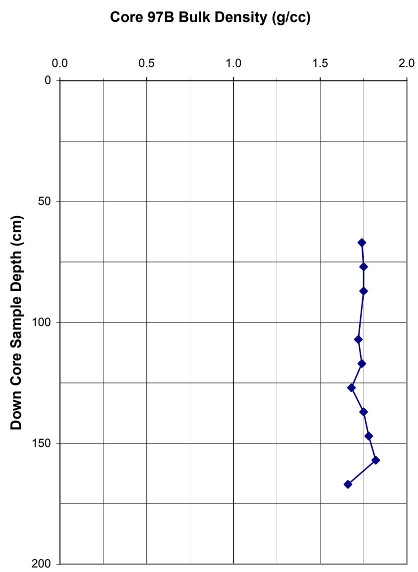
SAIC Sample ID	AMS Sample ID	W_c (%)	W_c-Salt Corrected (%)	Depth (cm)	Wet Unit Wt. (g/cm^3)	Depth (cm)	Dry Unit Wt. (g/cm^3)	G_s
97R-182	12090	67	72	182	1.61	182	0.96	-
97R-192	12091	71	76	192	1.60	192	0.93	-
97R-202	12092	69	74	202	1.61	202	0.95	-
97R-212	12093	70	75	212	1.64	212	0.96	-
97R-222	12094	66	70	222	1.63	222	0.99	-
97U+83	12095	18	19	83	1.76	83	1.49	-
97U+93	12096	21	22	93	1.88	93	1.56	-
97U+103	12097	19	20	103	1.80	103	1.52	-
97U-123	12098	61	65	123	1.69	123	1.05	2.68
97U-133	12099	70	75	133	1.61	133	0.94	-
97U-143	12100	71	76	143	1.61	143	0.94	-
97U-153	12101	63	67	153	1.64	153	1.00	-
97U-163	12102	78	83	163	1.56	163	0.88	-
97U-173	12103	50	52	173	1.75	173	1.17	-
97U-183	12104	87	94	183	1.51	183	0.81	-
97A+76	12243	20	21	76	1.89	76	1.58	-
97A+86	12244	19	20	86	1.78	86	1.50	-
97A+96	12245	22	23	96	2.00	96	1.64	-
97A-116	12246	63	67	116	1.63	116	1.00	2.67
97A-126	12247	67	72	126	1.59	126	0.95	-
97A-136	12248	65	69	136	1.68	136	1.02	-
97A-146	12249	69	73	146	1.66	146	0.98	-
97A-156	12250	63	67	156	1.70	156	1.04	-
97A-166	12251	54	57	166	1.73	166	1.12	-
97A-176	12252	58	61	176	1.66	176	1.06	-
97P+40	12253	19	20	40	1.83	40	1.53	-
97P+65	12254	19	20	65	1.75	65	1.48	-
97P+90	12255	21	22	90	1.82	90	1.50	-
97P+115	12256	15	15	115	1.70	115	1.48	-
97P+140	12257	16	17	140	1.75	140	1.50	-
97P+165	12258	18	19	165	1.80	165	1.52	2.68
97P+190	12259	19	20	190	1.79	190	1.50	-
97P+215	12260	20	21	215	1.75	215	1.46	-
97S+143	12261	21	22	143	1.72	143	1.50	-
97S+193	12262	20	21	193	1.84	193	1.53	-
97S+203	12263	25	26	203	1.80	203	1.44	-
97S+213	12264	22	23	213	1.82	213	1.50	-
97S-228	12265	50	53	228	1.76	228	1.17	-
97S-233	12266	58	62	233	1.69	233	1.07	2.64
97S-243	12267	58	61	243	1.66	243	1.05	-
97S-253	12268	58	61	253	1.68	253	1.06	-
97S-263	12269	66	70	263	1.64	263	0.99	-
97T+100	12270	18	19	100	1.72	100	1.46	-
97T+110	12271	21	22	110	1.77	110	1.46	-
97T+120	12272	22	23	120	1.82	120	1.50	-
97T-140	12273	43	45	140	1.78	140	1.24	2.66
97T-150	12274	70	75	150	1.66	150	0.97	-
97T-160	12275	70	74	160	1.59	160	0.94	-
97T-170	12276	44	47	170	1.77	170	1.23	-
97T-180	12277	67	72	180	1.57	180	0.94	-
97T-190	12278	54	57	190	1.70	190	1.10	-
97T-200	12279	68	73	200	1.63	200	0.97	-
97V+173	12280	17	18	173	1.71	173	1.46	-
97V+183	12281	28	30	183	1.91	183	1.49	-
97V+193	12282	22	23	193	1.78	193	1.46	-
97V-213	12283	35	37	213	1.88	213	1.39	2.69
97V-223	12284	41	43	223	1.82	223	1.29	-
97V-233	12285	55	58	233	1.75	233	1.13	-
97V-243	12286	22	22	243	1.83	243	1.51	-
97V-253	12287	23	24	253	1.74	253	1.41	-
97V-263	12288	13	14	263	1.67	263	1.47	-
97V-273	12289	114	123	273	1.41	273	0.66	-

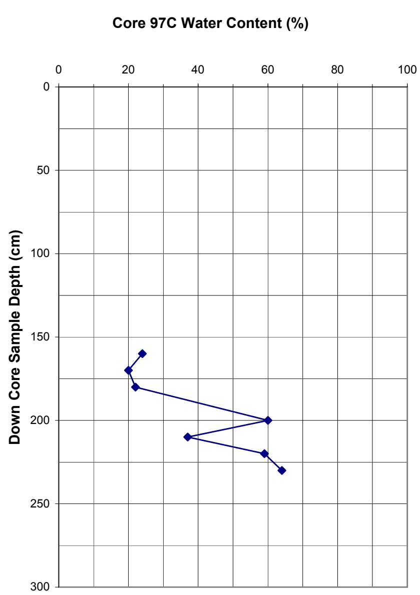
Appendix C-4
Plots of Water Content and Bulk Density with Depth in Each Core

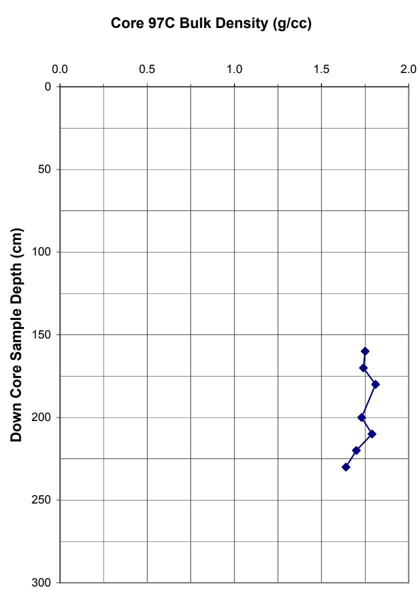

Core 97A Water Content (%)
0
20
40
60
80
100
0
50
100
150
200
Down Core Sample Depth (cm)

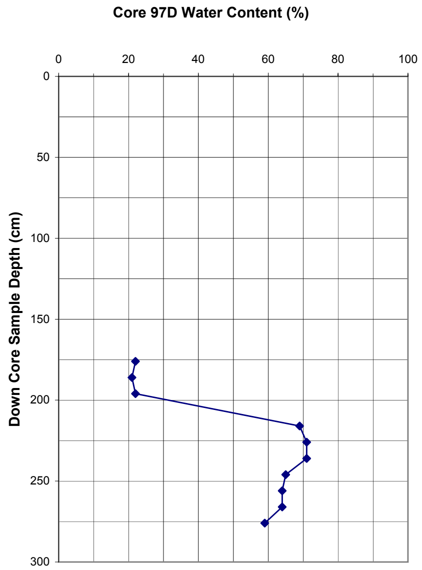

Core 97A Bulk Density (g/cc)
0.0
0.5
1.0
1.5
2.0
2.5
0
50
100
150
200
Down Core Sample Depth (cm)

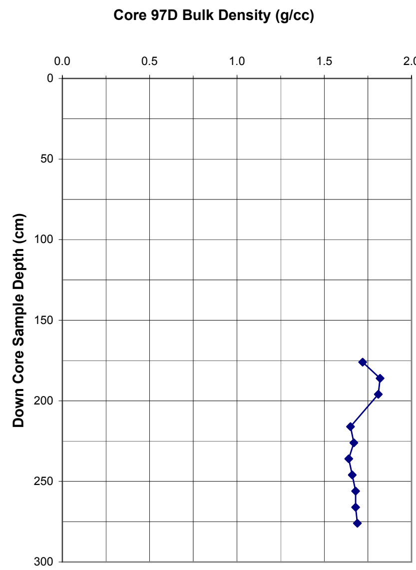

Core 97B Water Content (%)
0
20
40
60
80
100
0
50
100
150
200
Down Core Sample Depth (cm)

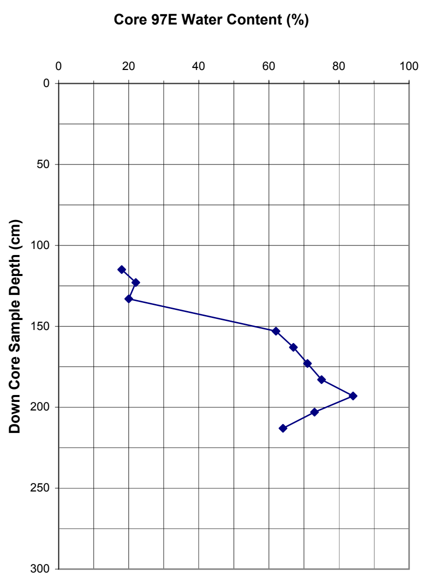

Core 97B Bulk Density (g/cc)
0.0
0.5
1.0
1.5
2.0
0
50
100
150
200
Down Core Sample Depth (cm)

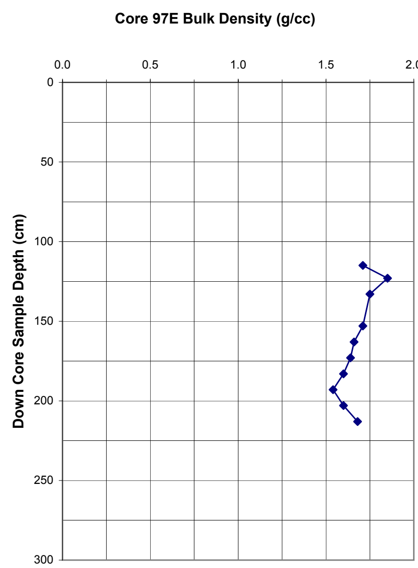

Core 97C Water Content (%)
0
20
40
60
80
100
0
50
100
150
200
250
300
Down Core Sample Depth (cm)

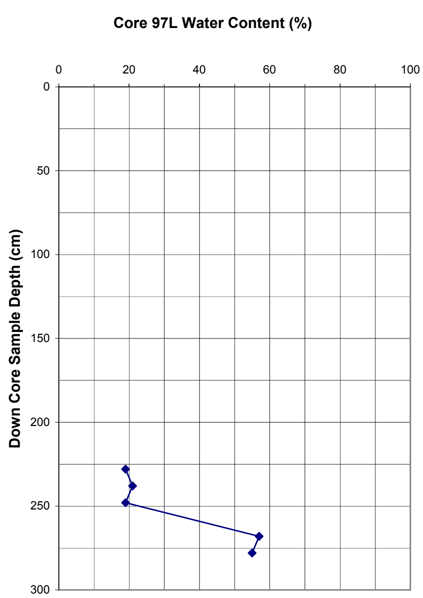

Core 97C Bulk Density (g/cc)
0.0
0.5
1.0
1.5
2.0
0
50
100
150
200
250
300
Down Core Sample Depth (cm)

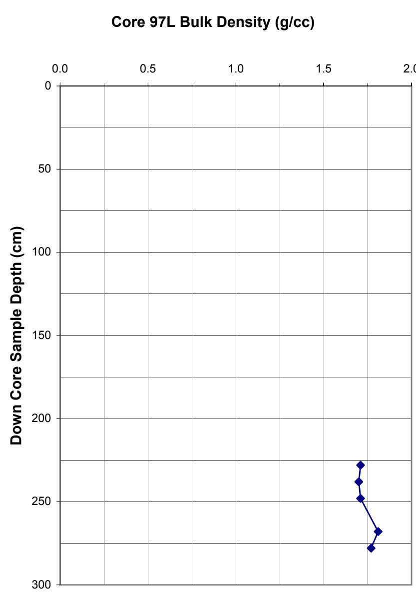

Core 97D Water Content (%)
0 20 40 60 80 100
0 50 100 150 200 250 300
Down Core Sample Depth (cm)

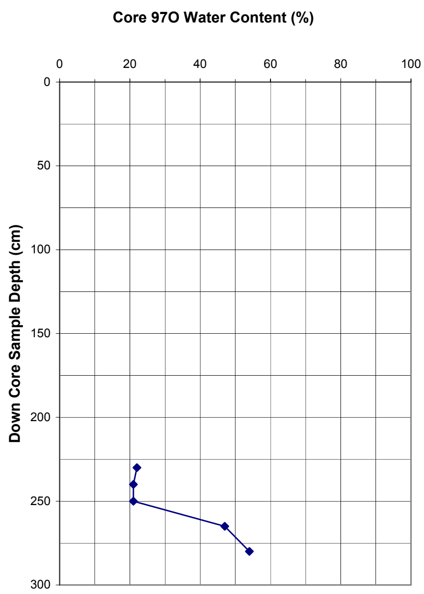

Core 97D Bulk Density (g/cc)
0.0 0.5 1.0 1.5 2.0
0 50 100 150 200 250 300
Down Core Sample Depth (cm)

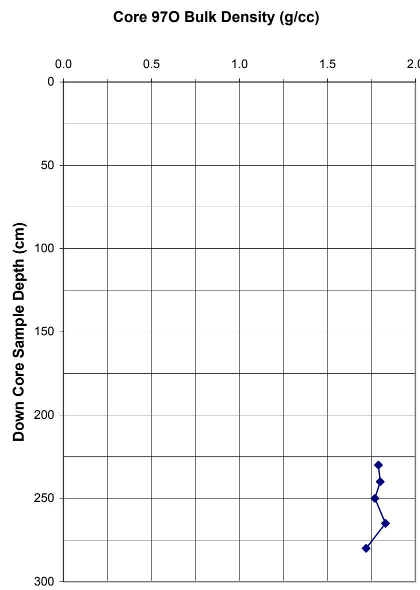

Core 97E Water Content (%)
0 20 40 60 80 100
0 50 100 150 200 250 300
Down Core Sample Depth (cm)

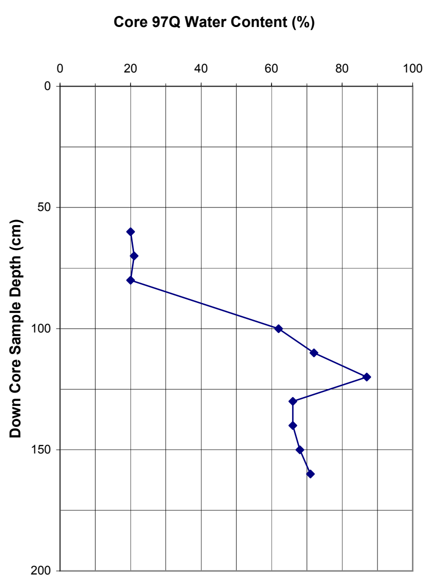

Core 97E Bulk Density (g/cc)
0.0 0.5 1.0 1.5 2.0
0 50 100 150 200 250 300
Down Core Sample Depth (cm)

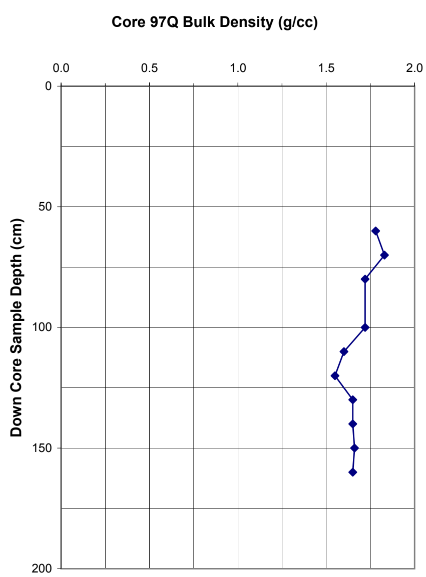

Core 97L Water Content (%)
0 20 40 60 80 100
0 50 100 150 200 250 300
Down Core Sample Depth (cm)

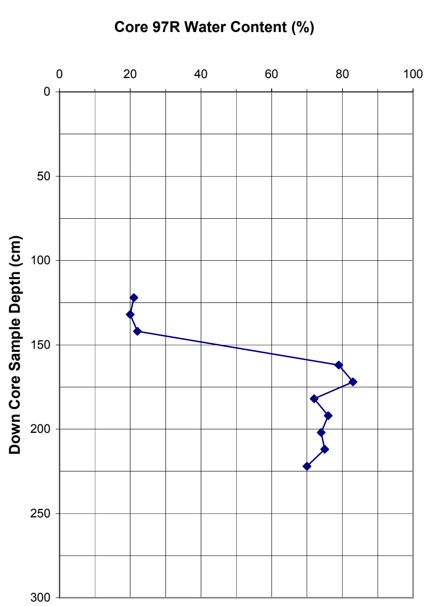

Core 97L Bulk Density (g/cc)
0.0 0.5 1.0 1.5 2.0
0 50 100 150 200 250 300
Down Core Sample Depth (cm)

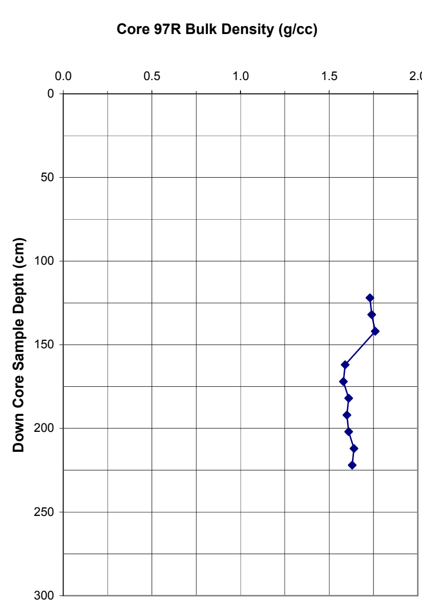

Core 97O Water Content (%)
Down Core Sample Depth (cm)
0
20
40
60
80
100
0
50
100
150
200
250
300


Core 97O Bulk Density (g/cc)
Down Core Sample Depth (cm)
0.0
0.5
1.0
1.5
2.0
0
50
100
150
200
250
300

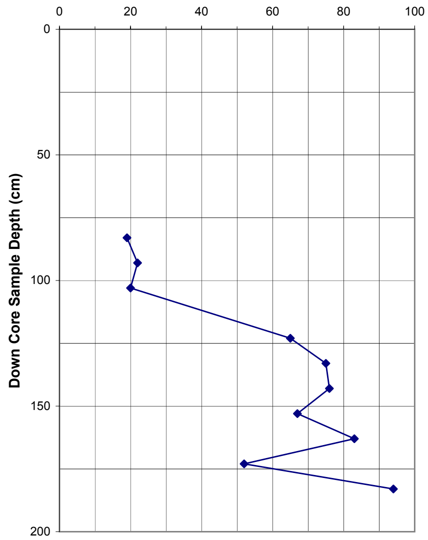

Core 97Q Water Content (%)
Down Core Sample Depth (cm)
0
20
40
60
80
100
0
50
100
150
200


Core 97Q Bulk Density (g/cc)
Down Core Sample Depth (cm)
0.0
0.5
1.0
1.5
2.0
0
50
100
150
200

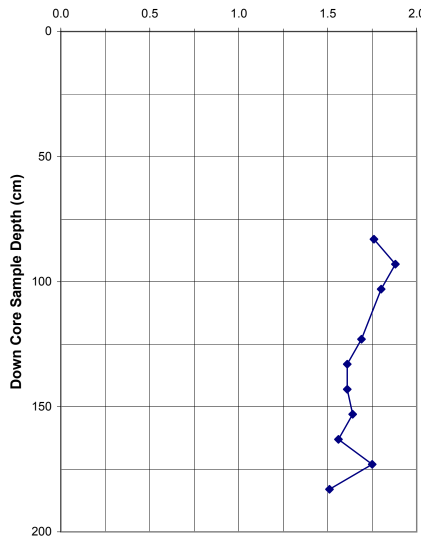

Core 97R Water Content (%)
Down Core Sample Depth (cm)
0
20
40
60
80
100
0
50
100
150
200
250
300


Core 97R Bulk Density (g/cc)
Down Core Sample Depth (cm)
0.0
0.5
1.0
1.5
2.0
0
50
100
150
200
250
300

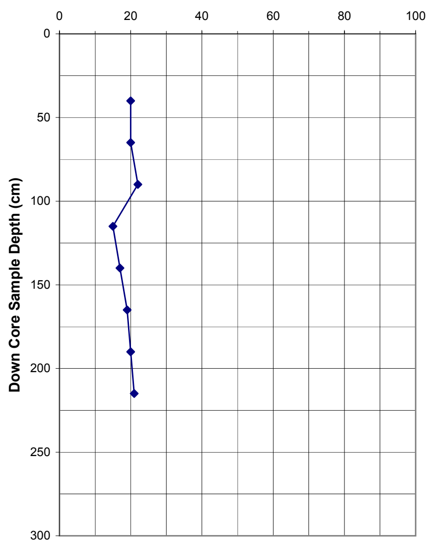
Core 97U Water Content (%)



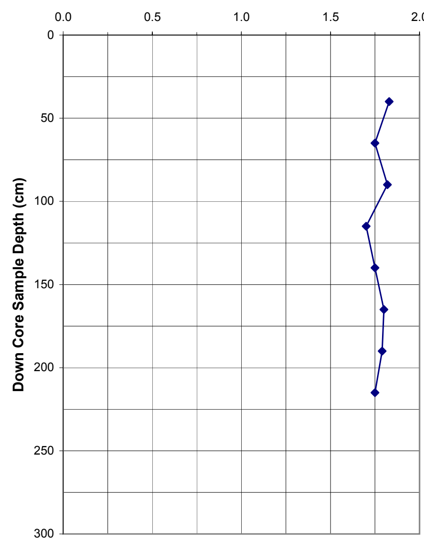
Core 97U Bulk Density (g/cc)



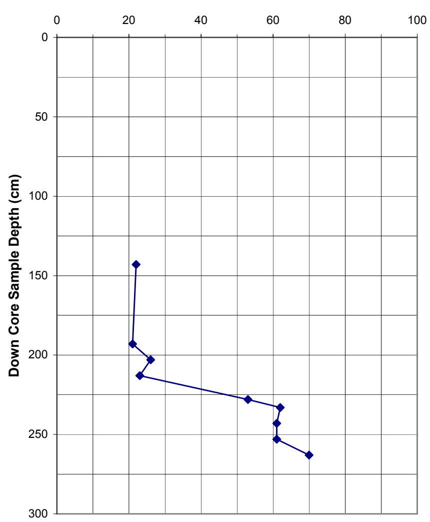
Core 97P Water Content (%)



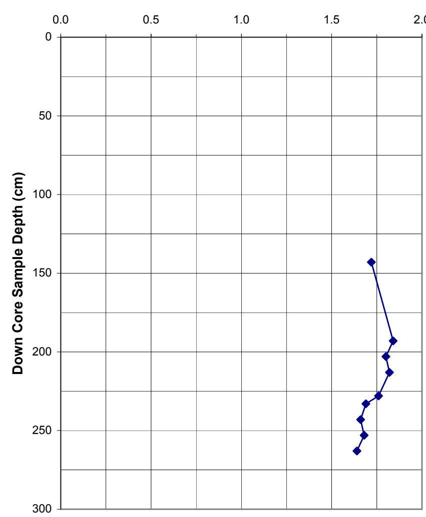
Core 97P Bulk Density (g/cc)



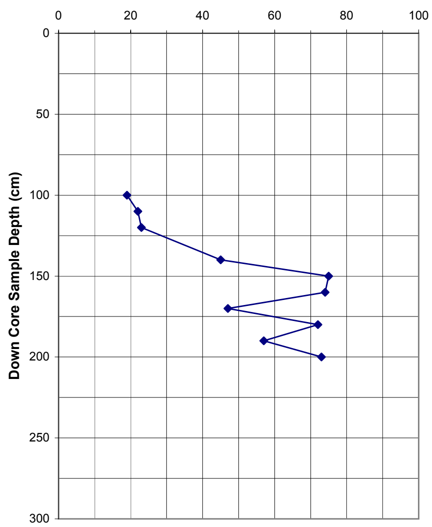
Core 97S Water Content (%)



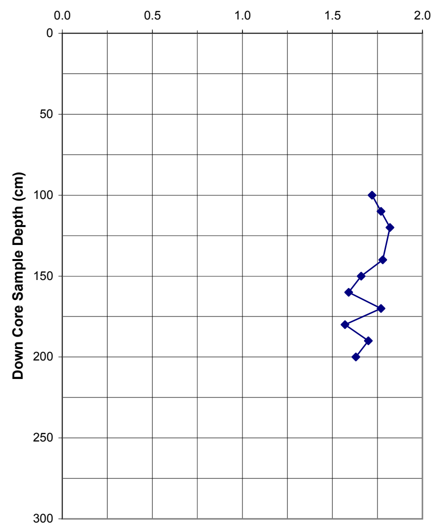
Core 97S Bulk Density (g/cc)



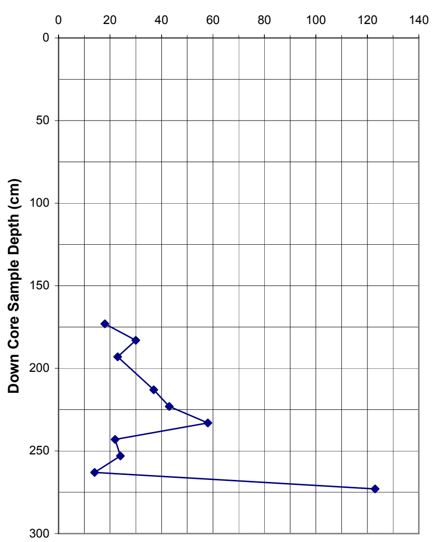
Core 97T Water Content (%)



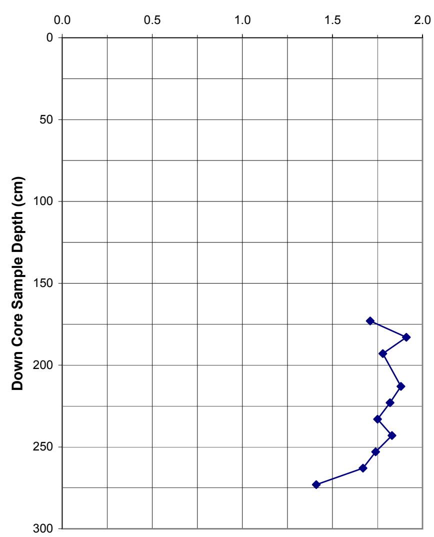
Core 97T Bulk Density (g/cc)



Core 97V Water Content (%)



Core 97V Bulk Density (g/cc)



Appendix C-5
Core Shear Strength Results

Appendix C-5
2002 Summary of Shear Strength Results for The 1997 Category II Mound

Core Station	Inner Degree of Rotation	Outer Degree of Rotation	Torque (Nm)	Shear Strength (kN/m^2)
97A	51	23	0.21	27.52
97B	80	22	0.32	43.17
97C	71	27	0.29	38.31
97D	58	15	0.24	31.30
97E	76	19	0.31	41.01
97L	88	25	0.36	47.49
97O	88	25	0.36	47.49
97P*	NA	NA	NA	NA
97Q	86	21	0.35	46.41
97R	54	24	0.22	29.14
97S	118	20	0.48	63.68
97T	55	21	0.22	29.68
97U	61	28	0.25	32.92
97V	19	11	0.08	10.25

* Core 97P contained all sand, preventing analysis for shear strength

Appendix C-6
Dioxin and Furan Concentrations in Each Core Subsample

Appendix C-6
Dioxin and Furan Concentrations in Each Core Subsample

CAP MATERIAL

Compound Name	97B+67	97B+87	97D+176	97D+196	97U+83	97U+103	97R+122	97R+142	97Q+60	97Q+80	97E+114	97E+134	Average	Stdev.	Minimum	Maximum	Sample Count
2,3,7,8-TCDF (furan)	0.1	0.095	0.1	0.1	0.085	0.1	0.095	0.1	0.1	0.095	0.1	0.095	0.10	0.00	0.085	0.1	12
2,3,7,8-TCDD (dioxin)	0.1	0.095	0.1	0.1	0.085	0.115	0.115	0.11	0.1	0.095	0.1	0.095	0.10	0.01	0.085	0.115	12
1,2,3,7,8-PeCDF	0.49	0.485	0.49	0.49	0.415	0.5	0.465	0.495	0.5	0.47	0.495	0.48	0.48	0.02	0.415	0.5	12
2,3,4,7,8-PeCDF	0.49	0.485	0.49	0.49	0.415	0.5	0.465	0.495	0.5	0.47	0.495	0.48	0.48	0.02	0.415	0.5	12
1,2,3,7,8-PeCDD	0.49	0.485	0.49	0.49	0.415	0.5	0.465	0.495	0.5	0.47	0.495	0.48	0.48	0.02	0.415	0.5	12
1,2,3,4,7,8-HxCDF	0.49	0.485	0.49	0.49	0.415	0.5	0.465	0.495	0.5	0.47	0.495	0.48	0.48	0.02	0.415	0.5	12
1,2,3,6,7,8-HxCDF	0.49	0.485	0.49	0.49	0.415	0.5	0.465	0.495	0.5	0.47	0.495	0.48	0.48	0.02	0.415	0.5	12
2,3,4,6,7,8-HxCDF	0.49	0.485	0.49	0.49	0.415	0.5	0.465	0.495	0.5	0.47	0.495	0.48	0.48	0.02	0.415	0.5	12
1,2,3,7,8,9-HxCDF	0.49	0.485	0.49	0.49	0.415	0.5	0.465	0.495	0.5	0.47	0.495	0.48	0.48	0.02	0.415	0.5	12
1,2,3,4,7,8-HxCDD	0.49	0.485	0.49	0.49	0.415	1.8	0.465	0.495	0.5	0.47	0.495	0.48	0.59	0.38	0.415	1.8	12
1,2,3,6,7,8-HxCDD	0.49	0.485	0.49	0.49	0.415	0.5	0.465	0.495	0.5	0.47	0.495	0.48	0.48	0.02	0.415	0.5	12
1,2,3,7,8,9-HxCDD	0.49	0.485	0.49	0.49	0.415	0.5	0.465	0.495	0.5	0.47	0.495	0.48	0.48	0.02	0.415	0.5	12
1,2,3,4,6,7,8-HpCDF	0.49	0.485	0.49	0.49	0.415	4.1	0.465	0.495	0.5	0.47	0.495	0.48	0.78	1.05	0.415	4.1	12
1,2,3,4,7,8,9-HpCDF	0.49	0.485	0.49	0.49	0.415	0.5	0.465	0.495	0.5	0.47	0.495	0.48	0.48	0.02	0.415	0.5	12
1,2,3,4,6,7,8-HpCDD	0.49	0.485	0.49	0.49	0.415	20	0.465	1.4	0.5	1.3	0.495	0.48	2.25	5.60	0.415	20	12
OCDF	1	0.95	1	1	0.85	16	0.95	1	1	0.95	1	0.95	2.22	4.34	0.85	16	12
OCDD	7.9	8.5	4.6	5.7	5.3	150	8.5	19	8.2	18	9	4.9	20.80	40.96	4.6	150	12
TEC	0.0079	0.0085	0.0046	0.0057	0.0053	0.58	0.0085	0.032	0.0082	0.03	0.009	0.0049	0.06	0.16	0.005	0.58	12

DREDGED MATERIAL

Compound Name	97B-107	97B-127	97D-216	97D-236	97U-123	97U-143	97R-162	97R-182	97Q-100	97Q-120	97E-152	97E-172	Average	Stdev.	Minimum	Maximum	Sample Count
2,3,7,8-TCDF (furan)	0.45	1	0.41	0.38	2.6	8.4	8.4	0.71	0.72	0.32	0.57	0.54	2.04	3.03	0.32	8.4	12
2,3,7,8-TCDD (dioxin)	0.99	4.3	1.1	1.2	5.9	22	3.3	1.3	0.97	0.43	1.3	0.4	3.60	6.04	0.4	22	12
1,2,3,7,8-PeCDF	8.8	29	2.3	3.5	45	150	4.9	4.5	7.7	3.1	0.485	0.49	21.65	42.59	0.485	150	12
2,3,4,7,8-PeCDF	0.495	1.9	0.5	0.485	2.6	13	4.9	0.495	0.55	0.245	0.485	0.49	2.18	3.67	0.245	13	12
1,2,3,7,8-PeCDD	0.495	0.465	0.5	0.485	1.3	2.7	4.9	0.495	0.55	0.245	0.485	0.49	1.09	1.37	0.245	4.9	12
1,2,3,4,7,8-HxCDF	0.495	3.3	0.5	1.8	3.6	16	12	0.495	1.3	0.245	1.2	0.49	3.45	5.12	0.245	16	12
1,2,3,6,7,8-HxCDF	0.495	1.5	0.5	0.485	2	16	11	0.495	0.55	0.245	0.485	0.49	2.85	5.11	0.245	16	12
2,3,4,6,7,8-HxCDF	0.495	1.5	0.5	0.485	2.2	8.4	4.9	0.495	0.55	0.245	0.485	0.49	1.73	2.48	0.245	8.4	12
1,2,3,7,8,9-HxCDF	0.495	1.4	0.5	0.485	0.485		4.9	0.495	0.55	0.245	0.485	0.49	0.96	1.34	0.245	4.9	12
1,2,3,4,7,8-HxCDD	0.495	0.465	0.5	0.485	1	4.8	4.9	0.495	0.55	0.245	0.485	0.49	1.24	1.69	0.245	4.9	12
1,2,3,6,7,8-HxCDD	0.495	1.4	0.5	0.485	3.5	15	4.9	0.495	0.55	0.245	0.485	0.49	2.38	4.23	0.245	15	12
1,2,3,7,8,9-HxCDD	0.495	1	0.5	0.485	2.1	7.2	4.9	0.495	1.1	1	0.485	0.49	1.69	2.15	0.485	7.2	12
1,2,3,4,6,7,8-HpCDF	4.6	16	4.2	4.7	31	140	62	6.2	4	1.3	3.9	2.1	23.33	40.75	1.3	140	12
1,2,3,4,7,8,9-HpCDF	0.495	1.1	0.5	0.485	1.8	11	4.9	0.495	0.55	0.245	0.485	0.49	1.88	3.15	0.245	11	12
1,2,3,4,6,7,8-HpCDD	17	24	22	16	53	240	55	17	21	19	19	16	43.25	63.46	16	240	12
OCDF	6.3	24	7.3	8.8	46	210	83	8.7	5.2	2.2	6.6	3.4	34.29	60.23	2.2	210	12
OCDD	660	610	610	630	870	2500	1400	660	830	700	540	760	897.50	552.78	540	2500	12
TEC	1.9	7.3	2	2.1	10	41	5.8	2.2	2.3	1.4	2.2	1	6.6	11.18	1	41	12